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The Atlantic Trust.

It is easy to over-value the material importance of the shipping combination recently engineered by Mr. Pierpont Morgan; but, notwithstanding, it has been the means of inflicting the greatest blow to the prestige of this country, as an industrial and maritime power, it has ever been compelled to endure.

The recent successful incursions of America—and in a lesser degree, Germany,—into what used to be regarded as an exclusively English sphere of manufacturing activity have been regarded, it is true, with uneasiness, but accepted, on the whole, with equanimity. The formidable attack now made upon the dearest of all British possessions—the supremacy of the seas—has aroused public feeling in a degree, which, if probably out of all proportion to its real importance, has evolved a movement which may be followed by the most momentous consequences to the Empire.

What are the facts? Mr. Pierpont Morgan has been successful in purchasing a line of British steamships at a cost out of all proportion to their actual value. This he has been induced to do by the fact that, having control of the chief American railways, he desires to extend that control so as to embrace the carriage of American-made goods across the Atlantic to, as near as possible, the point of consumption. If we are to restrict the bearings of his enterprise to this simple proposition, there is little to be said about the matter. The enterprise is a legitimate one, and in so far as its relations from this point of view are concerned, they affect no one excepting those who are parties to the transaction.

But there is another, and far more serious, aspect in which the Shipping Trust is to be considered; and that is the deliberate intention, betrayed in almost every line of the agreement entered into by the parties to the combination, of transferring the whole of the vessels comprised in the bargain to the American flag. There can be little doubt that the Atlantic Trust is intended to form the nucleus of a great American maritime establishment intended to drive British shipping off the seas.

The gigantic danger represented by the combination to the existence of England as a great maritime power has been sharply realised; and this full acceptation of its gravity is an assurance in itself to some extent that it will be confronted with promptitude and resolution. And it must be said that the momentary dismay created by such an unparalleled and apparently disastrous stroke as the transference of a great British fleet to a rival Power is greatly modified, if not altogether removed, on a closer examination of the circumstances surrounding the transaction.

In the first place, it is super-evident that the Trust starts on its career reeling under the weight of an enormous over-capitalisation. Unlike Mr. Morgan's twin achievement, represented by the United States Steel Corporation, whose different constituents were appraised with a strict regard to their value to the total organisation, the White Star Line, more especially, has been purchased on terms which the expression "a fancy price" inadequately expresses. Many of the vessels have more than reached their prime; and as the life of a first-class steamship is a short one, they must shortly be only fit to be passed out of service. In these circumstances, and under the normal conditions of commercial existence, the fate of the Atlantic Trust would be easily predetermined. It would necessarily come to grief within a very brief period. Unhappily the conditions are highly abnormal. The controllers of the shipping combination control also the railways providing the freights, which form so important a feature of the economical being of a trans-oceanic service; and it is a transparent

conclusion that no vessel not under the control of the Trust will be allowed to carry them. So far, then, Mr. Morgan holds the situation. American freights, which outweigh English freights in the proportion of more than three to one, will be confined to vessels of the Trust; and all ships outside the Trust will, so far as it can be contrived, be made to return to England from the American ports with empty holds.

A British Boycott.

Refraining from any contemplation of the problems which from a political standpoint rise into view as the result of this combination, it will be seen that from a strict commercial basis the whole question resolves itself into what will practically amount to a boycott of British-owned vessels by the American railways. The Trust vessels, in any case, will have preference. The British ships may, perhaps, be allowed to take what there may be left, although even that is doubtful.

What, then, might a people, not yet devoid of intelligence and vigour, be expected to do in face of such a menace? There are some—not, let us hope, visionary or super-sanguine—who discern, through a prospect at first sight sufficiently black and forbidding, gleams of light throwing radiance on a vista of undreamt-of possibilities: of an Imperial expansion, grand in its character and conception, by which, establishing yet more firmly, yet more enduringly, the power of the British Empire, may have (perhaps simultaneously) the effect of throwing Mr. Morgan's speculations in maritime supremacy to the winds.

Of all postulates referring to trade and commercial questions, one of the last to be disputed would be that the essence of all business transactions is *time*. Time is one of the main factors in all human affairs, but chiefly in that which affects the industrial life of a nation.

By the establishment, partly or wholly under British State control, of a line of steamships of greater speed, traversing a shorter route than that associated with the existing trans-oceanic vessels, it is not difficult to conclude that, whatever adventitious obstacles might be put in their way, the new line would be bound to triumph in the end.

A New Sea Route.

Such a sea route exists, and it lies between the Port of Bristol and another potential port in some part of the island of Cape Breton, lying close to the mainland of Nova Scotia. From the terminal of the ocean line in Canada, New York and all the chief American centres can be reached by railway in a few hours. Even with the speeds now current, at least twenty-four hours would be saved in the passage across the Atlantic. With the improved vessels, which, representing the very latest developments of marine architecture, it is computed the saving in time would amount to forty-eight hours, an advantage—in the conveyance of mails and passengers, at least—almost priceless.

Nor is the advantage to the publics of both sides of the Atlantic to be solely considered. The economy to the vessels themselves, by the shorter passage and the consequent contraction of expenses, would be considerable. Probably they might be enabled to compete successfully with the American-owned ships in this respect alone. The saving, on the assumption of a passage shortened by forty-eight hours, would amount to some two-fifths of the total expenses, a circumstance of great potential importance. New York, as the chief reception port of the United States, must inevitably be displaced in that respect by a port in Canada under the British flag; and last, though far from least, Canada would feel such a vivification throughout the whole veins of her corporate body as perhaps no country in the world has yet experienced.

British from Port to Port.

A whole stream of traffic, bearing with it new life and wealth to both participants, would result from the establishment of this great British trans-oceanic line of steamers—British from port to port, fed by British capital, and manned by British seamen. Such a line would form at once a weapon and a safeguard. The mere suggestion even of the possibility of having one day to use the vessels of an alien country to obtain access to our great Canadian Dominion, is simply

grotesque. It could not be endured for one moment.

It appears to us that Mr. Morgan in attacking Imperial sentiment (doubtlessly unconsciously) in his pursuit of what he doubtless considered a private bargain, has made his first great mistake. The auspices, from a mere financier's point of view, under which the Atlantic Trust is formed are bad enough in themselves. Considering the overwhelming over-capitalisation with which the Trust is burdened, even the most adroit manipulation of transit rates may be unsuccessful, not merely in paying a dividend, but in providing current expenses. What then must be the position of the Trust when confronted with a rival line of superior vessels, armed with greater speed, possessing the advantages of a shorter route; aided, not merely by State support, but backed by the Imperial sentiment of a whole nation?

The acquisition of the great Atlantic line, with its smaller congeners, has been greeted with extravagant applause in the United States, and aroused the most melancholy apprehensions at home. But we believe the great historical traditions of this country will be worthily supported at this present juncture, and that Mr. Morgan will ultimately find that it is not possible to tamper with the most cherished heritage of a great maritime nation with impunity.

British Electrical Engineering.

If to diagnose a disease is the first step towards effecting a cure, there is hope for the British electrical engineering industry. Unknown to, or forgotten by the vast majority of the members of the Institution of Electrical Engineers, its Council, about a year ago, appointed two committees to consider different aspects of the disadvantages under which the business is suffering. The reports of these committees have been issued within the past few weeks, and presented to the members of the Institution. One consists of a draft set of general contract conditions, which it was proposed should be adopted by the Council as their standard conditions for electrical contracts. The other report consists of a series of recommendations as to the need of modifying the laws which at present regulate the industry, and proposed that a deputation should be appointed to wait upon the Prime Minister, and call his attention to the existing unsatisfactory state of affairs. A further instance of the awakening of the Institution to a sense of its responsibility has also been given in the summoning of a conference of representative central station managers, to consider certain aspects of the Factories and Workshops Act of last year.

Before referring to the various proposals thus brought forward for the attention of electrical engineers, it is only fair to congratulate the Institution on its emancipation from that traditional line of policy, which, as one of the witnesses before its Committee on Electrical Legislation stated, "appears to have been towards scientific exclusiveness, ignoring the commercial and industrial progress of the science." If it has indeed awakened, although it cannot atone for the *laissez-faire* attitude of the past, it may do much to help in placing British electrical engineers in a position in which they can compete with foreign rivals on more equal terms than at present.

The draft general conditions were submitted for the approval of the members of the Institution as part of the programme of a recent meeting. Mr. Robert Hammond, at whose suggestion the committee preparing them had been formed, explained the principles upon which they were based, and claimed that, in preparing such proposals, the Institution was only following the precedent set by the Royal Institute of British Architects in reference to building contracts. The remarks made by the various speakers showed how deep was the wound caused by the stringent, unjust, and inconsistent general conditions it has become usual to embody in electrical contracts. The general tendency was to protect at all points the interests of the purchaser, or his representative the consulting engineer. Although the draft proposals bore evidence of a desire to be fair to all parties, one speaker remarked that while fifty-seven provisions were in

favour of the purchaser, there were only seventeen in which the rights of the contractor were safeguarded. The criticisms made were directed against the wording of the clauses, which all felt could be improved, the various speakers expressing their pleasure that the Institution had made an attempt to deal with this difficult problem. Mr. Hammond, on behalf of the committee, acknowledged the value of many of the suggestions, and promised them full consideration.

The report and minutes of proceedings of the Committee on Electrical Legislation form a very interesting document. This committee was formed in response to a wish expressed by the members at the close of the discussion on the paper read by Mr. Madgen on February 21st, 1901, upon "The Electrical Power Bills of 1900: Before and After," in which the legal disabilities of the industry were brought into prominence.

The committee was representative of all branches of the profession, and held in all eleven meetings, of which six were devoted to the consideration of evidence and examination of witnesses.

The points considered by the committee were :—

1. Causes leading to the present backward condition of the British electrical industry.
2. The practical advantages which could be secured by the development of electrical engineering schemes apart from reference to local government boundaries, and the effect of such schemes upon congested centres of population.
3. The amendments necessary to existing laws.
4. The simplification of present methods of procedure in obtaining powers to proceed with electrical schemes.
5. The methods by which closer co-operation of the Institution with Government departments, such as the Home Office and Board of Trade, could be best secured.
6. The best steps to take to give effect to their recommendations.

Evidence upon the above points was offered by Mr. Philip Dawson and Mr. J. Clifton Robinson, while statements were not only handed in by the following gentlemen, but they were examined before the committee :— Mr. W. L. Madgen, Lieut.-Col. Crompton, C.B., Alderman W. Ivey (of West Ham), Alderman G. Pearson (of Bristol), Mr. R. P. Sellon, Mr. A. A. Campbell-Swinton, and Dr. R. Spence Watson (of Newcastle-on-Tyne).

These statements, together with the questions and answers given in full in the report, form a trenchant indictment of the legislative enactments which for the past score of years have laid a heavy burden upon the industry. They also show the effect upon later developments of the over-speculation of the years 1882-5, and the results on actual progress of that tendency towards municipal trading, the growth of which has been practically concurrent with the rise of the business. Incidentally a number of other questions were raised, and the comments made upon the ever-increasing number of consulting electrical engineers — the virtues of the few, the otherwise of the many—are, to say the least, instructive; while it is refreshing to find that, while the paralysing results of undue pressure of political demands for the payment of non-competitive labour rates, are acknowledged and condemned, the working man is not wholly blamed for results his attitude was only one factor in producing.

The great advantage gained by our Transatlantic and Continental competitors during the years 1882-8, during which they were able to develop their manufacturing facilities, while our progress was retarded by the operation of the first Electric Lighting Act, was emphasised by several witnesses. Some laid more stress than others upon the effect which over-speculation had in the final result, but there was practical agreement as to the ill-advised efforts of our Legislature so to regulate as effectually to strangle a promising industry.

The Board of Trade overhead conductor regulations, the municipal preferences of the amending Electric Lighting Act of 1888, and the shortcomings of the Tramways Act of 1870, all receive their due meed of condemnation, and the recommendation to send a deputation to the Prime Minister to draw public attention to the matter seems to have been unanimous.

This committee has done good work, and if they only induce the members of the industry to follow the advice of one of the witnesses, viz. *Agitate*, they will not have been appointed in vain.

The conference of representative central station managers, convened by the Institution to consider the effect of the new Factories and Workshops Act, met, on the 12th ult., at the rooms of the Society of Arts. A large gathering unanimously adopted two resolutions, one declaring that the Act was prejudicial to the industry, the other approving of the appointment of a deputation to the Home Secretary, asking that the Institution be permitted to confer with him when he is framing the regulations governing the application of the Act to electrical generating and sub-stations. It would appear that these places had been included in the operations of the Act rather through ignorance of their real character than of deliberate intention. As Mr. Raworth remarked, anything more unlike the popular conception of a factory than a modern electric power-station it would be almost impossible to imagine. It was pointed out that unless exemptions were granted in the forthcoming final regulations, it would be impracticable to employ any young person under the age of 18 on nightwork, and compulsory to arrange for their taking all their meals outside the premises where work is being carried on. The powers which would be given to factory inspectors to insist upon modifications in the technical arrangements of working, were also considered as likely to cause much inconvenience. It was hoped by some of the speakers that the consideration of the matter had not been deferred too late, and before the close an assurance was given to the meeting that further steps would be taken as found necessary.

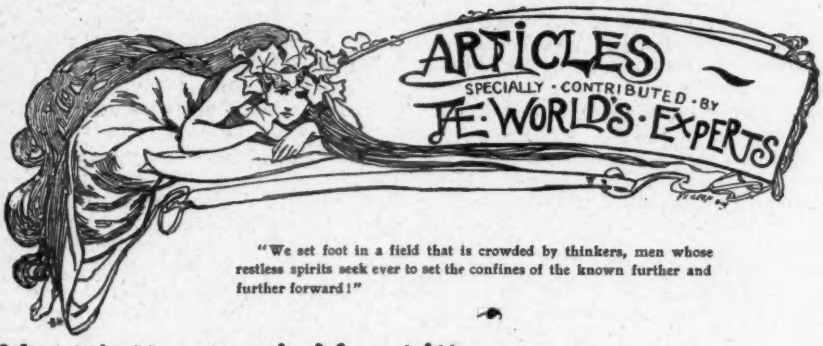
We do not wish to say one word in disparagement of the present energetic action of the Institution. One almost fears that the old proverb about the folly of locking the stable door after the steed had been stolen is applicable in the present case; we will, however, remember the more hopeful homely adage, "Better late than never," and welcome the Institution as a valued coadjutor in the work of guarding the interests of the British manufacturer.

The Triumph of British Locomotives.

It is a significant fact that none of those suffering from the desire to abase this country in the eyes of foreigners, have yet ventured to question the undoubted supremacy of the British locomotive. From all parts of the world come reports testifying to the superiority of the engines produced in Great Britain. On the Midland Railway in England, the American engines have been found to consume fully 20 per cent. more coal than the corresponding British type, to say nothing of other disadvantageous features; recent Russian experience is that 24 locomotives delivered from the Charkoff works have proved utterly unsatisfactory, and the administration has resolved in future to revert to the use of British engines; the head of the locomotive works of the Orange River Colony has lately stated that American engines cannot be compared with English ones; and the report, presented this year by Lord Cromer, is an overwhelming proof of the superiority of British locomotives in Egypt over those made in America and Belgium. In referring to the more important points dealt with in the latter document, we will first invite attention to the question of price. No comprehensive statistics are furnished showing the prices quoted in the past by French and Belgian firms, but from one or two examples given, it seems that those of the former were generally high, while those of the latter have usually been low. Further, it is stated that "the system of international competition (commenced in Egypt about 1887) seems to have had the effect of excluding French makers altogether, with the exception of the French works of the Franco-Belge Company"; and, again, that of the Belgian firms supplying engines one or two "can unhesitatingly be classed as second-rate," and one or two others "might perhaps compete on equal terms with any but the best British firms." As regards American makers, it appears that on seven recent occasions when tenders were invited, American offers were only twice received on the basis of the

specifications issued; and that on one occasion the American price was more than 20 per cent. above the most favourable British quotation, while on the other the excess was 10 per cent. On the other hand, the Baldwin Works offered, in response to each invitation, to supply engines of their standard types at prices that were about 19 per cent. lower than the British figures. The reason for this great reduction of price is explained by Mr. Trevithick, who says that the American firms would be able to introduce their stock patterns and to advance work continuously without being hampered by "unknown and unnecessary conditions." Without considering other factors it would be impossible for anyone to compare tenders fairly, but it is clear that British makers are fully able to hold their own in respect of price without taking into account superiority in quality, durability, and coal consumption. As regards the relative merits of Belgian and British engines, the statement is made by Mr. Trevithick that failures of Belgian engines—and they have been very frequent—are to be ascribed in most cases to the materials of the boiler; but the materials of the engine also compare unfavourably with those of English engines. The defects are mainly in the various alloys of copper used, occasionally in the cast-iron, and sometimes in the steel. An unusual proportion of minor breakdowns becomes evident when the engines are worked hard, and the average cost of repairs is so heavy that Major Johnstone states the Belgian-made engines will have cost, after 15 years, quite £750 more than the British-made engine of the same type, leaving out of account the expense indirectly caused by accidents and delays. American engines differ comparatively little from the British so far as the quality of material is concerned, but in workmanship there is a notable difference, for Mr. Trevithick says that, with the exception of working parts, the workmanship "is rough and far short of the finish that is considered desirable by European engineers." The cost of neatly finishing parts of a locomotive is very considerable, and goes far to account for the lower prices quoted by American firms for engines not in accordance with specification. But quite apart from the question of finish, American locomotives are characterised by other differences and disadvantages. In design the chief differences between American and British engines are the following:—(1) The fire-box and flue-tubes are of steel instead of copper; (2) the fire-grate is longer and narrower; (3) the cylinders and driving parts are outside instead of inside the frame; (4) a larger proportion of weight rests on the front wheels; and (5) the frames are of less rigid construction. The disadvantages following these differences are—(1) that the evaporative efficiency of the boiler is from 15 to 29 per cent. lower than that of the British; (2) that coal cannot be spread so evenly, and few firemen can throw coal to the end of the grate with precision; (3) that there is excessive cylinder condensation owing to the large surface exposed to the air, and the outside cylinders lead to waste of power in twisting strains on the engine and rails; (4) that the engines cannot start with so heavy a load, and the wheels slip during a run; and (5) that transverse strains occur on the coupling and connecting-rods, causing increased friction due to the flexibility of the frame. Further, it is found that increased friction and less perfect distribution of steam are due to the comparatively short eccentric rods of the American engines, and to the fact that they work the slide-valves through rocking levers, while in the British type the valve-rod is directly attached to the expansion link. In respect of coal consumption, the recent trials are of striking significance. The trials of British and American locomotives were carried out under exceptionally favourable circumstances, for the locomotives employed were typical of their respective countries in design and manufacture, while the trials were personally conducted and the results conjointly signed by a representative of the American builders and a locomotive inspector of the Egyptian Railway administration.

We shall, however, defer our consideration of these trials, together with the question of time of delivery, until our next issue.



"We set foot in a field that is crowded by thinkers, men whose restless spirits seek ever to set the confines of the known further and further forward!"

Ventilation and Humidity in Mills and Factories.

By H. R. CARTER.

DURING the last decade, the attention of spinners and manufacturers has been frequently drawn, by the operation of the various Factory Acts, to the ventilation of their mills and factories. For instance, the Cotton Cloth Factory Act of 1889, 52 & 53 Vict., ch. 62, sect. 9, provides that every apartment of a factory where artificial humidity is produced must be provided with means for the admission of at least 600 cub. ft. of fresh air per hour for each person employed therein. Again, under the Special Rules which the Secretary of State was authorised to make, by the Factory Act of 1891, for the spinning and weaving of flax, it was specified that weaving sheds artificially humidified must be provided with an efficient 14-in. extracting fan for every 2,500 sq. ft. of floor area. In the roughing and sorting shops also, exhaust fans were ordered to be provided so as to draw the dust forward and down from the face of the worker. Under the same rules the carding and preparing rooms had also to be provided with fans. In the Factory and Workshops Act of 1895, 58 & 59 Vict. ch. 37, sect. 1, it is enacted that 250 cub. ft. of air space shall be provided for each person employed. This, taken in conjunction with a supply of 600 cub. ft. of fresh air per head per hour, means that, if the space is just legally sufficient for the number of hands employed, the air must be changed rather more than twice per hour. In most modern mills the amount of air space per hand is well over the minimum, so that in many cases a complete renovation of the whole atmosphere *once* per hour is ample. In order that one may form an opinion as to the number of fans necessary to fulfil these conditions in any sized apartment, some idea must be gained as to the number of cubic feet of air which fans of various diameters and speeds can pass per minute or per hour. Taking the well-known Blackman fan as a standard, a 14-in. fan will "blow in" or "exhaust" approximately 1 cub. ft. of air per revolution per minute, or running at the usual speed of 1,000 to 1,500 revolutions per minute, it will move on the average, say, $1{,}250 \times 60 = 75{,}000$ cub. ft. per hour. One such fan then should provide $\frac{75000}{600} = 125$ persons with 600 cub. ft. of fresh air per head per hour in compliance with the Act. Larger fans run at speeds inversely as the pitch of their blades will move quantities of air approximately proportional to the area of their delivery surface. If the average velocity of the

air passed by the fan be known in feet per minute, its volume in cubic feet is the product of the former and the area of the delivery surface in square feet. The velocity of the air, of course, varies directly as the speed of the fan. In Blackman fans, driven at the usual speed, it varies from 1,000 to 2,400 ft. per minute. The instrument employed in finding the velocity of air currents is called an "anemometer," of which there are several forms which we cannot now describe. It will be sufficient to say that their action depends either upon the velocity imparted to a vertical spindle by the air current acting upon hemispherical vanes placed upon the end of radial arms, or on the pressure exerted by the current upon a plate directly exposed to it and measured by the compression of a spring, or on the height of a water column supported by the same pressure. As regards the latter, it may be said that the height of the water column supported is directly as the square of the velocity of the air, and that an air current with a velocity of 1,430 ft. per minute will support a water column $\frac{1}{4}$ in. in length.

The fans are usually set in frames in the outer walls of the building, or in a part of the window frame, the spindle of the fan being horizontal, and at right angles to its frame. For the ventilation of sheds, some recommend that the fans should be fixed with a vertical spindle, so that they will work horizontally about 8 or 10 ins. below the gutter line, thus giving a horizontal and diagonal draw upon the air, removing the hot atmosphere which rises to the top of the room without causing any draught upon the workers.

Ventilation upon the Tobin tube principle has been advocated for factory work. It consists essentially of a short vertical tube of wood or metal leading up the inside of the wall from the floor level to a height of 5 or 6 feet. Its lower end communicates with the outer air through a grating in the outside wall, and a stream of fresh air rises through the tube without change of direction until it reaches the upper portion of the room. Air can be moved in other ways than by fans, as we shall see later, when considering the mechanical means of producing humidity.

There are two distinct methods of artificial or mechanical ventilation, that is to say, the vacuum and the plenum systems. The distinction between these two lies in the fact that, in the former, the motive force, usually a fan, is placed at the *outlet*, and exhausts the vitiated air from the room, thereby *reducing* the internal pressure. Under the plenum system, upon the other hand, the fan is placed at the air *inlet*, and draws or forces the air into the room, thereby *increasing* the internal pressure. The advantages of the latter method are obvious, the chief being—that draughts are not so prevalent, and that we can be sure as to the purity of the air being introduced. Under the vacuum system, the air which is required to take the place of that removed may, and *does*, find its way in anywhere, it may be even from drains or closets. Were they not compelled to do so, manufacturers would find it to their advantage to look after the health of their hands in the way of good ventilation, for constant renewal of the air has such an invigorating effect upon the hands that the daily output is considerably increased, and there is a much smaller percentage of absentees through sickness.

Another point, as regards ventilation, has recently been called attention to by the case of H.M. Inspector of Factories *v.* Messrs. Hartley & Co., Preston. The cause of action was the alleged infringement by the defendant company of one of the special regulations made by the Secretary of State, pursuant of the power vested in him by the Cotton Cloth Factories Act of 1897. This special rule states that in no portion of the factory must the proportion of carbon dioxide, chemically known as CO_2, be greater than nine volumes to every 10,000 volumes of air. The case referred to went in favour of the defendants, since expert evidence showed that no system of ventilation is perfect and uniform, and that over 2,000 cub. ft. of fresh air per head per hour, a very large amount, were being introduced into the room. It has long been recognised as a fact that the state of the atmosphere as regards moisture has a great effect upon

the ease with which the spinning and weaving of vegetable fibres can be accomplished. Those countries or districts in which the rainfall is frequent and considerable, or which have large areas covered with water, which is constantly being evaporated and absorbed by the surrounding atmosphere, are found to be most suited to the spinning and weaving of such fibres.

The appreciation of this fact by spinners and weavers is shown by the manner in which these industries have found their chief seat in those countries whose climate and local conditions are best suited to their requirements. Ireland and Belgium are two such countries, which for this reason have become seats of the linen trade, which remains and flourishes there, while other countries, such as the United States of America, although taking the lead in other branches of industry, must own after frequents attempts that their country and climate are not suitable for the spinning of linen yarns, especially in the finer counts.

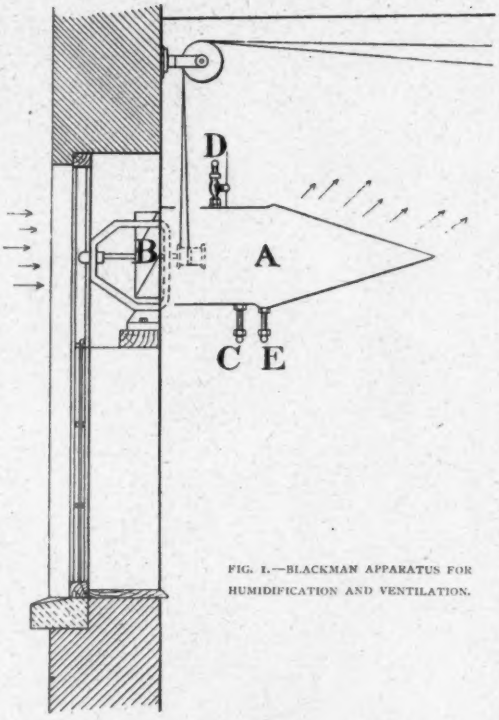


FIG. 1.—BLACKMAN APPARATUS FOR HUMIDIFICATION AND VENTILATION.

That the humidity of the atmosphere does exercise an influence on the ease with which the preparing, spinning, and weaving operations are accomplished, no practical flax-spinner will deny, in the face of the difficulties he meets with when unfavourable weather sets in. In the flax and tow preparing room, the "drawers" find on a cold, frosty morning, or when a dry March wind is blowing, that, if the slivers do not actually lap themselves upon the pressing rollers, so much fibre is carried away by the rollers and deposited upon the rubbers that the sliver is rendered lighter by an appreciable amount. Under such conditions, too, the rove is much more "hairy," and requires more twist to strengthen it on account of the fibres not binding so well together through lack of moisture. In the spinning-room, too, under such conditions, if the temperature be not raised and maintained, the room will be thrown into confusion by the wholesale "dropping" of ends, which is particularly noticeable in fine numbers, and may be caused even by a draught from door or open window. In linen and cotton weaving sheds the production or "turn off," as well as the quality of the weaver's work, is greatly lowered in dry weather with easterly wind and frost, the atmosphere then abstracting from the yarn much of its natural moisture, rendering it brittle, and increasing the number of broken threads and other weaver's faults.

No air is ever absolutely dry, although in the British Isles the east wind is often relatively so. Sometimes, especially in some districts, we experience an opposite state of the atmosphere when the air is saturated with moisture which condenses

on every heat-absorbing object. The air on a summer day which we would consider to be fairly dry, might in reality contain a much larger quantity of moisture than does the air upon a winter's day when much rain has fallen. It is not the *quantity* of moisture contained in the air with which we must concern ourselves, it is its capacity for absorbing more. Warm air is capable of holding in suspension a much larger quantity of aqueous vapour than is cold air. When air at any temperature contains as much moisture as it is capable of absorbing, it is said to be saturated. Dew-point is the temperature at which air is just saturated with a given quantity of moisture. If the dew-point is high the air contains a large quantity of moisture. If the air contains a small quantity of moisture the dew-point is correspondingly low. The temperature of dew-point is best obtained with the aid of an instrument known as an hygrometer, the form with which manufacturers are best acquainted being known as a wet and dry-bulb thermometer. This instrument consists of two standardised thermometers, which have been compared at Kew Observatory with a standard thermometer to determine their index errors. The thermometers should be so mounted that there is a distance of at least $3\frac{1}{2}$ ins. between the bulbs, in order that the evaporation from the wet bulb or from the water reservoir may not affect the dry bulb. The bulb of the wet thermometer should be covered with thin muslin, and a conducting thread of coarse cotton tied loosely round to secure it to the bulb. The loose ends of the conducting thread are placed in a small reservoir of water, which must be kept full. The instrument should be placed in a central position in the room, in the shade, and with the bulbs at a height of about 4 ft. from the floor. The action of the hygrometer is as follows. The dry bulb thermometer, of course, indicates the actual temperature, while the wet bulb indicates the temperature of evaporation, which is less than that of the atmosphere. When the two thermometers indicate exactly the same no evaporation is taking place. The temperature of dew-point and the hygrometric state of the air, or the exact percentage of humidity, can be ascertained in the following manner from these two readings. To obtain the former we make use of what are known as Glaisher's factor, which for ordinary temperatures are as below:—

Fahrenheit.	Factor.	Fahrenheit.	Factor.
32° to 33°	3·1	50° to 55°	2·0
33° to 34°	2·8	55° to 65°	1·8
34° to 35°	2·6	65° to 70°	1·7
35° to 40°	2·5	70° to 75°	1·5
40° to 45°	2·3	75° to 80°	1·3
45° to 50°	2·1	80° to 85°	1·0

We then multiply the difference between the temperature of the wet and dry bulb by that factor which corresponds with the temperature of the air at the time of observation, and subtracting the product thus obtained from the temperature, as indicated on the dry bulb, we get the temperature of the Dew point. For instance, suppose that the dry bulb indicates 75 degs. Fahr. and the wet bulb 73 degs. Fahr., the temperature of dew-point is then $75^\circ - [(75^\circ - 73^\circ)\ 1{\cdot}5] = 72^\circ$. It will be noticed that Glaisher's factors decrease in amount with increase in temperature. For this reason, the Cotton Cloth Factories Act of 1889 requires that the difference in readings of the wet and dry bulb thermometers should vary from 2 degs, at a temperature of 60 degs. to 8 degs. at a temperature of 95 degs., in order that the temperature of dew-point may be well below the temperature of the atmosphere, which will then be relatively dry. According to the Act just quoted, 52 & 53 Vict., Ch. 62, Sect. 5, the amount of moisture in the atmosphere of the factory must not exceed 11·5 grains per cub. ft. When this maximum weight is present, the temperature must be correspondingly high, namely, 95 degs., at which temperature the air will only be saturated to the extent of 66 per cent., which is denoted by the wet bulb thermometer standing at 87 degs. If the wet bulb stand higher than this, the dew-point is nearer the temperature of the atmosphere, and the air more thoroughly

saturated. The relative humidity, denoting a state of saturation as 100 and absolute dryness as zero = 0, may be calculated from Apjohn's formula, by dividing the elastic force of saturated vapour at dew point by the elastic force or tension at the temperature of the air, and multiplying the quotient by 100. According to Apjohn's investigations the elastic force of saturated vapour at dew-point may be ascertained from the formula

$$F = f - \frac{d}{88} \times \frac{b}{30}$$

where F is the tension required, f the elastic force at the temperature of evaporation, d the difference between the wet and dry bulbs, and b the barometric pressure. When the readings of the wet bulb are above 32 degs., as in practice, they usually are, f is found from Regnault's values of the elastic force of vapours, and d and b are observed.

While we are posessed of instruments such as hygrometers, there is no reason why they should not be more used than they are at present, to warn us when the state of the atmosphere is not advantageous to the processes in which we are engaged, the most favourable temperature and degree of humidity having been arrived at by experience. Numerous systems have been invented for artificially supplying hot and cold air, either alone or combined with moisture as required to bring the atmosphere of the room into any required state. The writer's attention was first drawn to the subject some eleven years ago by seeing a system at work in a linen-weaving factory in the North of Ireland. As far as recollection serves, the plant consisted of a small shed situated outside, but in close proximity to the factory building. Besides a door, which was kept shut when at work, there were two openings, one for admitting the outside air, situated close to the floor upon one side of the shed, and the other at a higher level, closed by a fan and connected by a duct with the weaving shed. Inside the shed, and surrounding the air inlet, was a built-up pile of wooden laths,

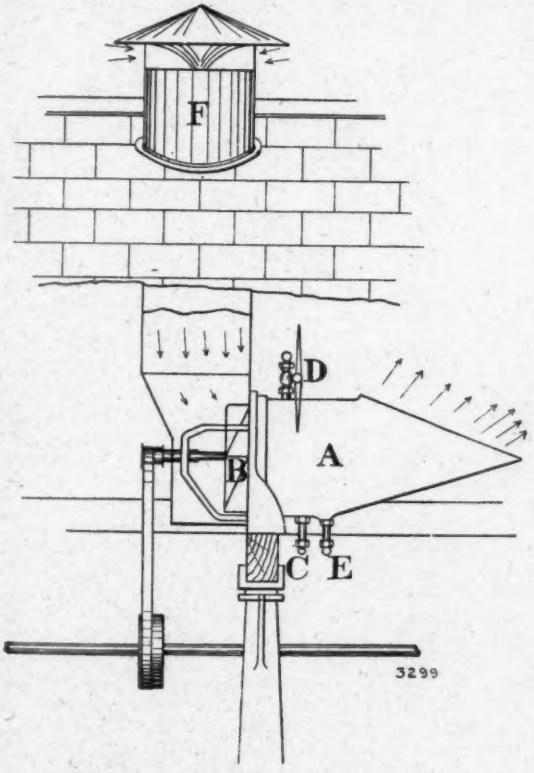


FIG. 2.—ANOTHER BLACKMAN APPARATUS FOR HUMIDIFICATION AND VENTILATION.

upon the top of which a water cistern was supported and kept supplied with fresh water from the town main. The bottom of the tank was perforated with holes, so that the water constantly dripped upon the pile of laths underneath, keeping them saturated with moisture. The fan partially exhausted the air from the shed, expelling it into the factory. Fresh air was con-

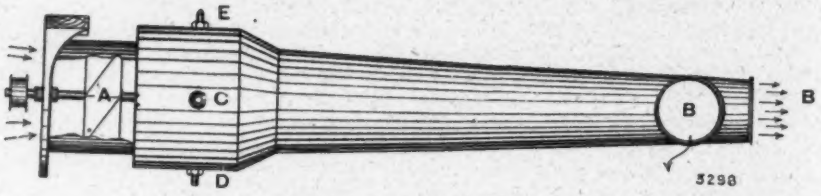


FIG. 3.—MATTHEWS AND YATES' PATENT CYCLONE HUMIDIFIER.

sequently constantly entering by the air inlet, and, passing through the pile of moist laths, absorbed a quantity of moisture, when it issued through apertures in the air duct and was dispersed through the shed. It kept the atmosphere fresh and invigorating for the workers while maintaining the yarn in its best working condition. As far as recollection goes, no means was provided for heating the air in winter. It might easily have been done by heating the water or by inserting a steam coil on either side of the fan.

A system of which the writer has had considerable practical experience when applied to flax-preparing rooms, is that of the Blackman Ventilating Company, of London. Like the last, it combines humidification with ventilation, and, when required, with heating. Fresh air is drawn from the outside by a fan, and, passing through a water spray, is forced into the room, the vitiated air being expelled by fans upon the opposite side. In order that the air may take up as much as possible of the water provided, the latter is finely pulverised, so that a large part of it is carried into the room by the current of air in a nebulous form. The apparatus employed may be briefly described with reference to the accompanying figures. Fig. 1 shows the humidifier *A*, consisting of a zinc funnel with a mouthpiece opening upward, attached to the frame in which the fan *B* is set, and which is inserted in the upper half of the window, as shown.

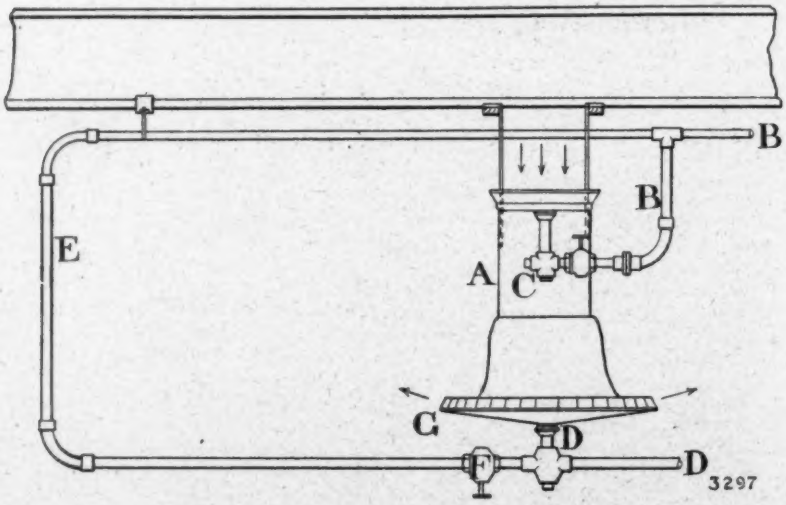


FIG. 4.—VORTEX HUMIDIFIER AND AIR PURIFIER.

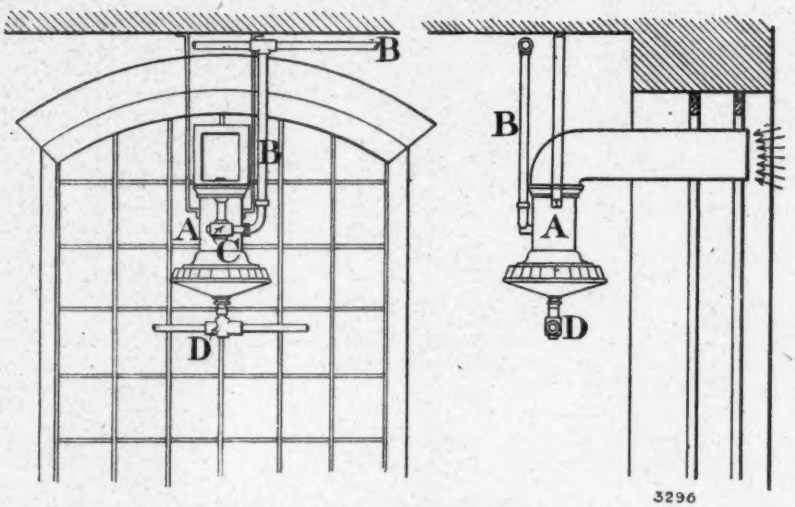


FIG. 5.—VORTEX AIR PURIFIER CONNECTED THROUGH A WINDOW.

Water is supplied to the apparatus by the pipe *C*, from a cistern which supplies the whole system. The vertical branch from the water-supply pipe *C* projects upward into the zinc funnel, and is furnished at its extremity with a nozzle. The water-level in the cistern is kept constant by a ball-cock, and it is essential to the proper working of the system that this water-level should be, say, ½ in. below the mouth of the nozzle, and that every humidifier supplied by the same cistern should be exactly upon the same level. *D* is a pipe supplying compressed air from an airometer, which is filled by an air pump. The air issues at high velocity from the nozzle of the air pipe, close to the opening of the water pipe, and, producing a partial vacuum, the water is drawn or forced up, and, striking a small metal disc in a fine jet, is pulverised into spray, which the current of air from the fan carries into the room. *E* is a drain-pipe, which carries away any heavy drops of water which are not absorbed by the air-current. Each humidifier has a cock for shutting off the supply of compressed air when *humidity* is not required, the fan, of course, still continuing to act as a ventilator. In cold weather steam, instead of water, may be admitted thus, at the same time warming and moistening the air. If it be intended to use steam, the steam or water supply pipe should be provided with expansion joints. Fig. 2 shows the method of attaching the same apparatus to a beam in the middle of the room, the fan drawing in the air through a duct, *F*, of equal area, which projects through the roof. The circular cast-iron framework of the fan has a flange cast upon it, by means of which the apparatus is secured to a beam. The Cyclone Ventilo-Humidifier (Matthews & Yate's patent) is of somewhat similar construction and principle to that just described. Fig. 3 represents the apparatus, which may be attached to a vertical or horizontal air-duct communicating with the fresh air through the roof or window. Air is drawn in by the small propeller *A*, and then blown through a fine spray of water, which moistens it. A small jet of steam is added, so that the water may be considerably warmed when required. The humidified air issues into the room through the three apertures *B B B*, which tend towards more equal diffusion. *C* is the water-supply pipe, *E* the steam connection, and *D* the overflow

in the lower portion of the apparatus. This system is being employed to advantage in flax-preparing rooms, cotton-weaving sheds, silk mills, and many other places.

The American Sturtevant or blower system is well known in the United States, where it has been installed in many cotton, silk, and jute mills. In principle it resembles the method which we first mentioned. Large fans or blowers, such as are seen on passenger steamboats, are located in the basement or at some other convenient point. These fans, which may be conveniently driven by a small direct-acting vertical steam engine, draw in the outside air, and, passing it through or over steam pipes in coils and a spray of steam or water placed in the main duct when required, distribute it about the building through ducts built into the walls, or through metal pipes provided for the purpose.

We will now describe a type of humidifier which in its working causes a draught or movement of the air, which may be taken advantage of for the purpose of ventilation and renewal of the atmosphere. A very good apparatus of this sort is that known as the Vortex. Fig. 4 shows the apparatus used as a simple humidifier and air purifier. Figs. 5 and 6 show the same connected by a duct with the fresh air, in Fig. 5 through the window, and in Fig. 6 through the roof of the building. When applied in such a way it serves at the same time as a ventilator and a humidifier in a manner which we will now describe. In Figs. 4, 5, and 6, *A* represents the cylinder or body of the humidifier proper, *B* the feed-pipe from a pump, *C* the nozzle on the end of the feed-pipe and inside the cylinder of the humidifier, and *D* is the return pipe for returning the surplus water to the pump reservoir. Fig. 4 shows the feed and return pipes connected by a by-pass *E*, which, when the apparatus is at work, is closed by the valve *F*. When this valve is opened the return pipe is flushed by water, at high pressure, from

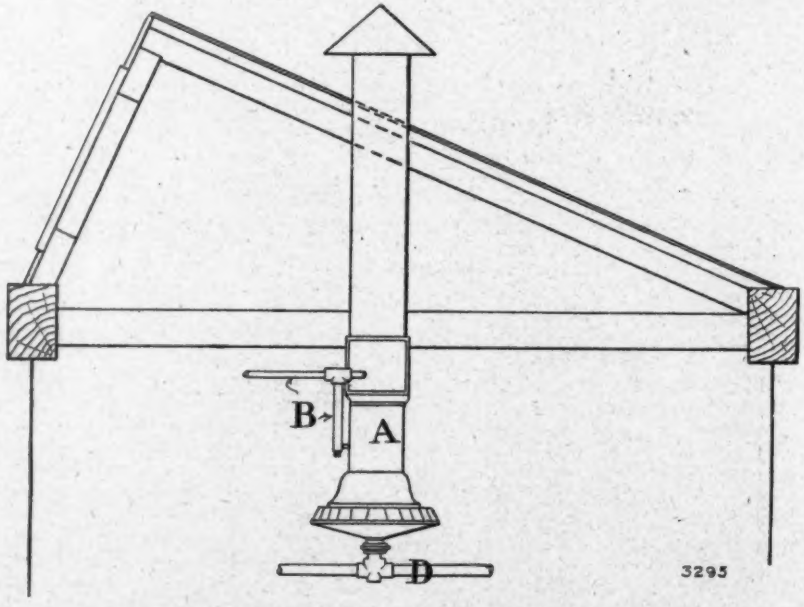


FIG. 6.—VORTEX AIR PURIFIER CONNECTED THROUGH A ROOF.

the feed-pipe, thus preventing any accumulation of dirt, dust, etc., removed from the air by the water. Water from the pump is forced from the feed-pipe through a filter, and then through a nozzle *C*, impinging in a perfectly straight jet upon the flat end of a hardened nickle pin. The water is, in this way, split up into minute particles, seen as vapour, which takes the form of a hollow cone, with the head of the pin as apex. Taking this form, it pushes a considerable volume of air before it, and, creating a partial vacuum in its rear, the air rushes down from the top, in Fig. 4, or in from the outside, as in Figs. 5 and 6. It is claimed that each ventilating machine will, in this manner, pass 36,000 cub. ft. of fresh air per hour. This air, when passing through the cone of vapour, will absorb 26 lbs. of water per hour, the jet passing about one gallon per minute. The majority of the water returns through the pipe *D* to the tank supplying the pump. The humidified air passes out through the lower portion *G* of the humidifier, and mingles with the surrounding atmosphere. Its proper distribution, as well as the removal of the hot and vitiated air, is assisted by the use of ordinary exhaust fans upon the other side of the room. In summer cold water is used, but in winter the water may be heated if desired. A direct-acting steam pump, with an air chamber on the feed pipe, is best adapted for the work. The use of a steam pump is preferable to that of a power pump, in that the apparatus may be started to work in the morning, an hour or so before the arrival of the workers, and a favourable state or condition of the air secured at starting time.

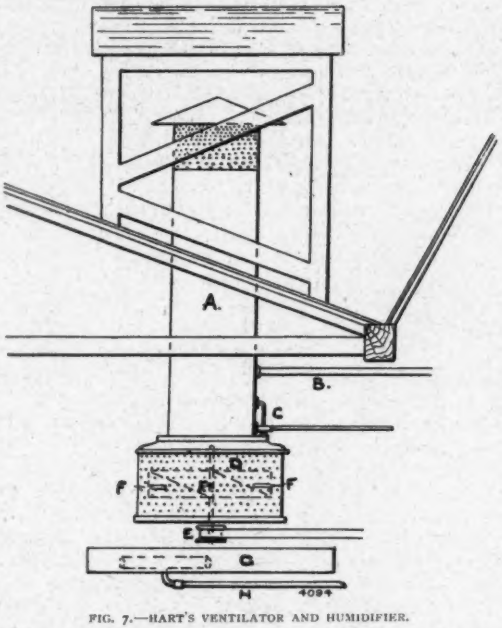


FIG. 7.—HART'S VENTILATOR AND HUMIDIFIER.

Hart's system of ventilating and humidifying, although placed last, is by no means the least successful. It has a decided advantage over some, in the fact that it possesses no long horizontal air-ducts or pipes which now, by legislation, require to be kept clean internally. The apparatus, Fig. 7, consists of a vertical circular air-duct *A*, passing through the roof and furnished with a conical hood to prevent rain, etc., from falling into the apparatus. A steam coil is placed in the air-duct so that the incoming air may be heated when desired. *B* is the steam pipe supplying the coil. The vertical drain pipe *C*, connected with the tail end of the coil, carries off water of condensation released by a steam trap. The air-duct is enlarged at its lower extremity into a chamber formed of perforated zinc sheeting. In the interior of this chamber *D* is a fan usually 20 ins. in diameter, its shaft vertical and supported, as is the whole apparatus, by brackets attached to the beams overhead. A flanged pulley *E* is keyed upon the lower end of the fan spindle which by this means may be driven from the line shaft at a speed of say 1,250 revolutions per minute. The perforated zinc chamber *D* has several nozzles or outlets *FFF* upon the same

central plane as the fan. The latter being rotated, fresh air is drawn down from the outside, heated when desired, and projected in minute streams, capable of easy diffusion through the perforated sides and nozzles of the fan chamber.

A humidifying attachment *G* is hung below the fan. It is a circular double trough containing a steam pipe fed by the pipe *H* as shown. The steam when turned on rises through perforations, and is intimately mixed with the air currents issuing from the fan chamber. In hot weather all steam is dispensed with and the air cooled and damped by causing the air, which is being drawn in by the fan, to come in contact with cloth sheets, which are kept constantly moist by a stream of water flowing over them from a trough above.

We have tried to impress upon spinners and manufacturers that healthy conditions of work are a direct gain to themselves as well as to the workers, and in a concise manner to place before them, firstly, the obligations with which the law obliges them to conform, and, secondly, the means at present at their disposal for fulfilling such obligations. In doing so, we leave the choice of fans, humidifiers, etc., to their own discretion, and hope that these few remarks will show some light to anyone to whom the subject is of practical interest.

H R Carter

The Design of High-Speed Steam Launches.

By DAVID KIDD.

Most of the launches built to-day by firms engaged in the business, have a really high rate of speed when compared with that of the fastest ocean-liners. The layman thinks very little of a 56-ft. vedette pinnace, such as is carried on board ships of the Royal Navy, travelling at the rate of 15 knots per hour, yet this speed corresponds to that of an ocean-going liner, 600 ft. long, at 49 knots an hour. No attempt has yet been made to build such a vessel, and there is no immediate prospect of such becoming practicable. Why can the 600-ft. ship not go at 49 knots speed, in view of the assertion often made—that higher speeds can be got by increasing the linear dimensions? The reason is, that this statement is often only true up to a certain point; that is reached when the speed exceeds a certain ratio of the displacement; then the boat begins to rise bodily, partially out of the water, resulting in a decrease of the displacement and wetted surface, leading to higher speeds, because these two items are the chief factors in causing resistance.

The phenomenon of rising occurs when the ratio of the direct resistance to the displacement, $\frac{\sqrt{2}}{D^{\frac{2}{3}}}$, attains a certain value. The rising speed of the 56-ft. pinnace referred to occurs at 13·5 knots, while the rising speed of the 600-ft. ship is at 46 knots. From what has been stated, and from what follows when dealing with this question when considering power, the fact may be deduced, that all launches having any claim to be considered fast, run at or over the crucial vicinity of the rising speed. The great advantage of designing a launch to travel at a high speed is that it will run very easily at a fast speed; her movements then are the movements of ease; but to ensure such there must be that harmony of proportion which alone can assure perfection of action.

By proportion is meant the relation which length, breadth and draft bear to each other, and to the displacement. These must be arranged to insure speed and stability, for both are largely influenced by the proportions of the linear dimensions. The first general idea we have is that speed depends greatly upon length; the second is that stability is strongly influenced by the ratio of the mean draft to the moulded breadth. The next most important consideration affecting choice of proportions is that there is a certain proportion of breadth and draft which ensures a minimum of wetted surface for any given type of similar length and displacement, provided other wetted surfaces, such as keel, shaft brackets and rudder, remain constant in area.

Weight has nothing to do, directly, with the speed of a launch; but the quantity of water displaced and manner of displacing it require to be seriously considered. The fastest launches are all distinguished by an extremely low ratio of breadth to length; and by having a very small percentage of the displacement of the rectangular block enclosing the immersed portion of the hull, excluding the keel; this percentage is known as the "block co-efficient." It is perfectly obvious that a full-bodied launch will not be so fast as a finely modelled launch of similar proportions and power but having less displacement.

The ratio of the breadth at the load water-line and the mean draft amidships are the determining factors for stability so

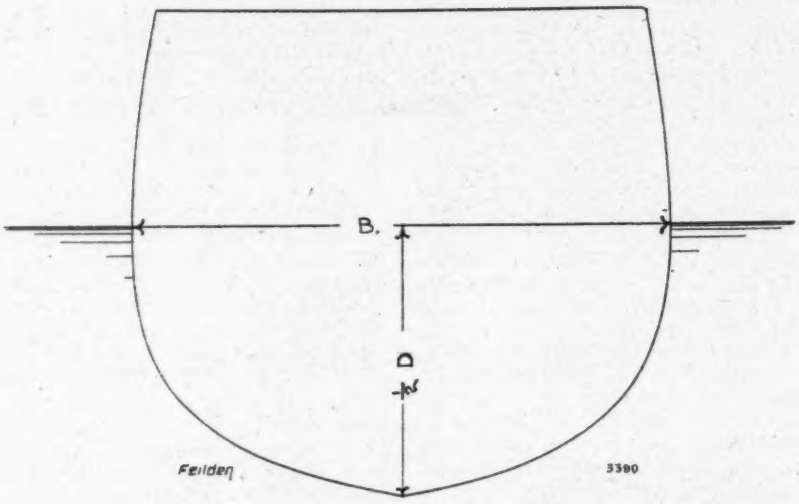


FIG. 1.—DESIGN OF HIGH-SPEED STEAM LAUNCHES.

far as proportions are concerned. The mean draft of the fast pinnaces and vedette boats for sea service is generally about $\frac{1}{3}$ of the breadth, when there are no special restrictions placed on draft as would be if the launch were required for service on shallow rivers. To get the best results it is advisable to have the $\frac{\text{Depth}}{\text{Breadth}}$ somewhere between $\frac{1}{3}$ and $\frac{1}{2\cdot5}$, and to keep the load water-line fairly full at the ends, and in lieu of this to cut away the deadwood so as to keep the stability right. The centre of gravity of hull and machinery should be placed as low down as possible in high-speed launches, as these boats are much more tender than the ordinary type.

As afore-mentioned there is a certain ratio of draft to breadth, which ensures the minimum possible of wetted surface for any launch of given length and displacement; and as a large portion of resistance to speed arises from the wetted surface, the proportions should be kept as closely as possible to that ratio. The following table of wetted surface, calculated from rectangular block-shaped vessels 16 ft. long, and each having a displacement of 64 cubic feet in salt water, shows how the area of wetted surface varies with the different proportions of draft to breadth.

Figs. 1 and 2 show graphically where the minimum wetted-surface occurs, viz.: at the ratio $\frac{D}{B} = \frac{1}{2}$. These figures and diagrams show clearly that the area of wetted surface may be directly influenced by proportions alone: this fact will have

Number	1	2	3	4	5
Length	16′	16′	16′	16′	16′
Breadth	4′	6′	3′	2′	1′
Draft	12″	8″	16″	24″	48″
Displacement, cubic feet ...	64	64	64	64	64
Displacement, tons	1·828	1·828	1·828	1·828	1·828
Displacement $\frac{2}{3}$	1·505	1·505	1·505	1·505	1·505
Wetted surface, square feet ...	104	125	98·65	104	152

to be borne in mind when considering power formulæ.

The importance of length for speed getting purposes, arises from the fact that the wave-making resistance is greatly influenced by the length of the immersed hull. It is apparent that "high speed" and "low speed" are only comparative terms, and what might be a very high speed for one launch, would be quite low for another; 10 knots would be quite a high speed for a launch 20 ft. long, but a very ordinary speed for a 100 ft. launch.

The law of corresponding speeds is that in comparing launches of similar form and proportions with one another, the speeds must be proportional to the square root of their linear dimensions. Thus for the launches afore-mentioned, the speed of the 20 ft. boat corresponding to the 100 ft. launch at 10 knots would be $\frac{100}{20} = 5$ and $10 \div \sqrt{5} = 4{\cdot}5$ knots per hour.

The influence of breadth upon speed has now to be considered; and particularly the relation of breadth to length as affecting the stream-line motion and wave-making resistance. The water must be displaced and replaced gradually in order to minimise this resistance; consequently the fastest launches are all narrow in proportion to their length compared with ordinary launches. In large fast boats of 50 ft. and upwards the proportion of breadth to length varies from $\frac{1}{7}$ to $\frac{1}{9}$ in extreme cases; between 30 ft. and 50 ft. the ratio is about $\frac{1}{6}$, and in the case of very small launches of about 20 ft. to 30 ft. it is about $\frac{1}{5}$ to $\frac{1}{4}$. Generally, the smaller the launch becomes the higher does the ratio $\frac{B}{L}$ rise, because a certain amount of stiffness is required to

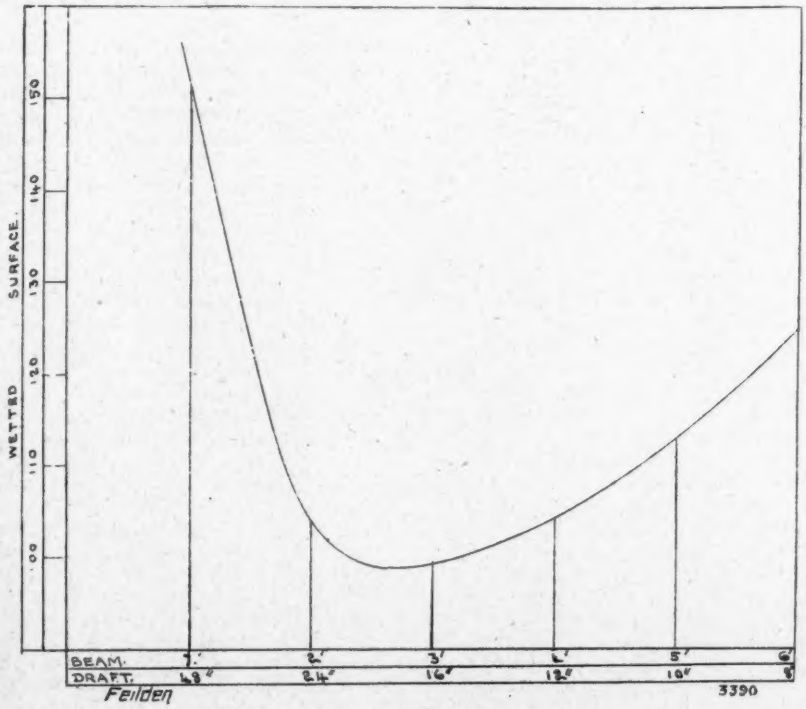


FIG. 2.—DESIGN OF HIGH-SPEED STEAM LAUNCHES.

FIG. 3.—DESIGN OF HIGH-SPEED STEAM LAUNCHES.

enable the crew to move about with some freedom from the danger of excessive listing, and it is this consideration that renders increase of beam necessary where the displacement is small compared to the weight of crew, &c.

Next to length, displacement is the greatest factor for speed. It is a common mistake to imagine that a short heavy boat can be driven at a high speed. This is really impossible of being accomplished, because every increase of weight added, whether in the shape of machinery or otherwise, involves a corresponding increase in displacement and wetted surface, and consequently to an increase in the resistance. To overcome this more power must be added, and this, of course, leads to additional weight of machinery.

With an unsuitable hull required to be driven at a high speed the weight of machinery would sink the boat before the speed could be approached. The weight of water displaced is, of course, equal to the weight of the launch; and the great consideration in high-speed work is to have this as small as possible. The amount of water displaced is generally expressed as a co-efficient of the rectangular block enclosing the mean immersed portion of the hull; this co-efficient is known as the block co-efficient, thus

$$\frac{\text{Displacement} \times 35}{\text{Length} \times \text{Breadth} \times \text{Draft}} = \text{Block co-efficient.}$$

The 56-ft. pinnace referred to at the beginning of this article had a block co-efficient of 0·42, and is a very familiar type of medium-sized fast launch; co-efficients of fast launches vary from ·3 to ·45. Fast torpedo-boats and torpedo-boat destroyers have the block co-efficient as low as ·25.

The skin resistance forms a goodly proportion of the total resistance at high speeds, and a very large proportion at low speeds; it varies approximately as the square of the speed. Wave-making resistance of high-speed launches is caused principally by the diverging waves at the bow and stern, and the transverse series of waves which get mixed up with the bow and stern waves. The distance from crest to crest of the transverse waves varies as the square of the speed at which the launch is moving. This distance may, and often does, exceed the length of the launch, and then "squatting" takes place, as the bow and transverse wave-crests keep the fore body of the launch up, while the stern sinks in the trough between the wave-crests. When in such a position a launch is said to be climbing a wave, or squatting; this attitude is illustrated by Fig. 3.

Theoretically, there is no known limit to the speed at which a launch may be driven. Practically, launches are designed to give a certain speed, and are powered to attain neither more nor less than that speed. The practicable limit of speed for small fast launches may be found by an approximate empirical formula based on the law of corresponding speeds;—

$$x = 30 \div \sqrt{\frac{100}{L}}$$

where L is the length on the load water-line of the launch. Higher speeds might be attained than those given by the above formula, which is based upon the trial result of the fastest torpedo boats and destroyers, if steam turbine machinery be used. This type of motor is very suitable for these high-speed launches, as the high number of revolutions allow of smaller

slip and more efficiency in the propeller than is usual in launch work.

As was casually noticed in the opening paragraphs, the launch begins to rise out of the water when the ratio of the resistance to the displacement $\frac{V^2}{D^{\frac{1}{3}}}$ attains a certain value. By trial results of torpedo boats and fast launches, this value is found to be approximately 9, so that the approximate speed at which a launch will begin to rise is given by $V = \sqrt[6]{D}$. The following figures may prove interesting, as they give the displacement and rising speed of small fast launches.

Tons Displacement.	Rising speed (Knots.)
$\frac{1}{2}$	7·992
1	9·000
2	10·062
6	12·123
10	13·203
15	14·121
20	14·823

Fig. 4 shows a curve of rising speed for any displacement up to 20 tons.

The effect of the rising speed upon power, and the system of approximating power for speed may now be examined. Any formula intended to ascertain the i.h.p. required to drive a launch at a certain speed, must be used in conjunction with accurate speed and power trial data, or else be empirical in its construction and based on experience. The more closely the dimensions, proportions, and block co-efficients of the proposed and actual launches agree, the more correct will be the approximation for power.

The most popular power formula used to-day is the Admiralty displacement co-efficient of performance of previous launches, found thus :—

$$\frac{D^{\frac{2}{3}} \times V^3}{I.H.P.} = C$$

$$\frac{D^{\frac{2}{3}} \times V^3}{C} = I.H.P.$$

$$\sqrt[3]{\frac{I.H.P. \times C}{D^{\frac{2}{3}}}} = V$$

where D is the displacement in tons, V the speed in knots, and C the Admiralty co-efficient. The co-efficients obtained from the trial of existing launches should always be carefully registered, so that they may be applied to any proposed launch. In practice it is found that this co-efficient

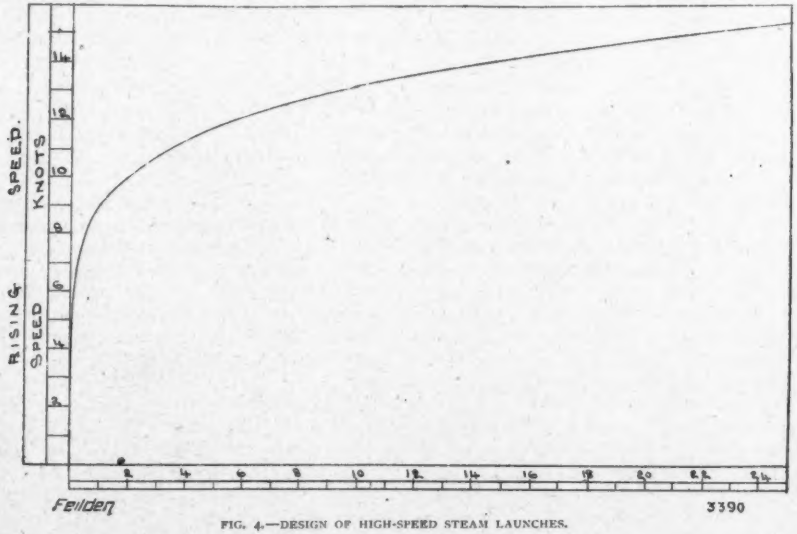


FIG. 4.—DESIGN OF HIGH-SPEED STEAM LAUNCHES.

varies about from 50 to 100 in launches from 30 to 60 ft. long, and of fairly fine form and proportions, at the rising speed. The $D^{\frac{2}{3}}$ in the formula is, of course, another expression of the value $^3/_{D^2}$; it is found convenient in practice, when it is desired to derive a number of values, to run a curve of $D^{\frac{2}{3}}$ through the extreme limits of the displacements. Any intermediate value may then be scaled off as required. It will be seen that the Admiralty co-efficient varies between rather wide limits; it attains a maximum at a certain speed, and falls for either higher or lower speeds, because at high speeds the resistance varies at a greater rate than V^2, although the machinery co-efficient of performance is high; at low speeds the resistance varies nearly as V^2, but the machinery co-efficient is not at its maximum value.

The assumptions made in using this Admiralty co-efficient are four in number. 1. The resistance is supposed to be proportional to the speed. 2. That the resistance is also proportional to the area of wetted surface, and that this area varies as the $D^{\frac{2}{3}}$ power of the displacement. 3. The type, efficiency, and co-efficient of performance of the machinery are assumed to be the same. 4. The condition of the wetted surface must be the same in both cases.

This formula may be applied to launches which are not similar, and whose efficiency of propulsion differs; but the greater the similarity in hull, machinery and speed, the greater will be the degree of accuracy in evaluating the i.h.p. or speed. On referring to Figs. 1 and 2, and the accompanying table, comparing the wetted surfaces of five rectangular block launches of similar length, displacement, and $D^{\frac{2}{3}}$, the necessity of having the proportions of the actual and proposed launches somewhat similar is at once apparent, it being evident that $D^{\frac{2}{3}}$ is only a ratio of the wetted surface when the proportions correspond. Frictional resistance depends on wetted surface; and if the proportions of a launch be changed, the value of the Admiralty co-efficient may be expected to differ. The launches compared should also be fitted with the same type of engine and propellers. If steam resistance were the only resistance, then the latter would undoubtedly vary as the square of the speed; but at high speeds it forms from one-half to one-third only of the total resistance; and so this assumption gets farther away from the truth as the speed increases. The Admiralty co-efficient curve in all high-speed launches gradually increases from a very small value at low rates until a certain speed is reached, which requires about one-sixth of the total trial i.h.p. At this point it attains a maximum value, and at higher speeds gradually decreases at an almost constant rate.

The co-efficient curve does not continue to fall indefinitely. When the neighbourhood of the rising speed is reached the value of the Admiralty co-efficient is at a minimum; beyond the rising speed the value increases—due to the launch bodily rising out of the water, and so causing a decrease in displacement and wetted surface—and steadily rises thereafter. It follows that the larger the boat the higher will the Admiralty co-efficient be, provided the rising speed is not reached; but if it is exceeded then the smaller the launch the higher will be the co-efficient.

There is an empirical method of calculating directly the i.h.p. required, which is very suitable for moderately high speeds, and valuable as a check on the Admiralty co-efficient method. It is based on Rankine's Augmented Surface theory; thus

$$\frac{W.S.\ (1 + 4S^2 + S^4)\ V^3}{20{,}000} = I.H.P.$$

W.S. being the actual wetted surface as found from Kirke's analysis, or from actual calculation. *S* is the sine of $\frac{1}{2}$ angle of entrance, found by Kirke's Analysis; and *V* is the desired speed in knots per hour. This formula is found to give very accurate results in practice.

It will be seen that the Admiralty co-efficient method of calculating i.h.p. involves a knowledge of the displacement. Now the weight of the machinery cannot be accurately determined until the i.h.p. is known, so that a rough guess at the power required must be made from the

performance of previous launches before the weight making up the displacement can be estimated; and any necessary correction of the displacement due to the i.h.p. as found by the Admiralty co-efficient should then be made.

The weight of the machinery is usually estimated by co-efficients based on a similar type of engine of the same power, approximately; these are expressed by the ratio weight ÷ i.h.p., where the weight is in tons. For C.S.C. fast-running launch engines developing about 200 i.h.p. the co-efficient runs about ·025, and for smaller engines of this type it is ·035. These co-efficients are necessarily used in the preliminary stages of design, the actual weights being separately estimated by the engineers.

The method of estimating the weight of the hull is by means of the cubic number co-efficient, which is

$$\frac{L \times B \times D}{100} = \text{cubic number};$$

L being the length between perpendiculars; B the moulded breadth; and D the depth in linear feet; the weight is obtained from the cubic number of the proposed launch, thus:—Cubic number × co-eff. = weight of hull. The co-efficient is obtained from the ascertained weight of similar existing launches: $W \div \left(\frac{L \times B \times D}{100}\right)$.

The smaller types of fast steam launches ranging in size from 20 to 40 ft. are generally open boats having a cubic number co-efficient of ·050, and as the launches get larger this diminishes to ·025 in boats about 60 ft. long having a ratio of breadth to length of $\frac{1}{7}$. Breadth increases the cubic number co-efficient value, while decrease of the ratio $\frac{B}{L}$ decreases the co-efficient. The exact weight of the hull is taken out by minute and detailed calculation after the lines and scantling plans have been made. This co-efficient is only used for the preliminary stages, like the machinery co-efficient.

In estimating the probable weight of coal required for these little vessels, the usual consumption of C.S.C. machinery is about 3 lbs. per i.h.p. per hour, and 5 lbs. in non-condensing types should be allowed for. Water and other extras are included by the machinery co-efficient and the remaining weight, the crew is taken out by the designer according to the number it is intended to carry, allowing 144 lbs. per man.

From the reasons advanced when dealing with wave and frictional resistance we know that the necessity of having the weight as low as possible is of paramount importance; the greater the speed demanded, the more urgent does that necessity become; in launches required to be driven at a rate much beyond the rising speed, the desired speed can only be obtained at the expense of strength, efficiency and comfort, where the launch has ordinary construction and machinery, even although each be the best of its kind it is possible to design or obtain. The only factors which at this moment seem to forecast speeds beyond the present limit are nickel steel, and the steam-turbine engine, which will allow of lighter displacement than that now practicable. Aluminium has been tried for the construction of the hull, but it becomes covered with a white deposit and rapidly corrodes, rendering it on that account unsuitable.

David Kidd

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Finding the Velocity of Projectiles.

By H. G. TICEHURST, M.I.Mech.E.

It is possible, by using the chronoscope invented by Sir Andrew Noble, to ascertain the velocity of a projectile along the bore of a gun by noting the time taken for the shot to travel along measured distances of the barrel. When the times occupied in traversing these known intervals have been accurately observed, the mean velocity of the shot over these intervals can be obtained by means of the simple formula

$$\frac{\text{space}}{\text{time}} = \text{velocity}$$

A velocity curve to a distance base can then be plotted, as in Fig. 1, and from this the rate of change of velocity (acceleration curve) is laid down to an appropriate scale, then the total mean force urging the projectile forward can be derived from Newton's second law of motion

$$F = MA$$

Where M = mass of projectile $= \frac{w}{g}$

„ A = mean acceleration in ft.-secs. per second

The total mean force, multiplied by the length in feet of the barrel will give the work done in the barrel, and as this work is taken up by the shot (neglecting the friction of driving-band, etc.), as it leaves the gun, we get

$$FL = \frac{WV^2}{2g} = \text{kinetic energy of shot}$$

Where W = weight of shot in lbs.

„ V = velocity of shot (muzzle)

„ g = acceleration due to gravity

therefore $$V^2 = \frac{FL\ 2g}{W}$$

and $$V = \sqrt{\frac{FL\ 2g}{W}}$$

A second method of obtaining velocity is by means of the Ballistic pendulum only applicable to rifles and guns of small calibre.

A pendulum consisting of a block of wood or lead is suspended by two rods on knife edges in such a way as to prevent the block from twisting. The rifle is fired straight at this block, and some means must be taken to ascertain the maximum swing of the block after being struck by the bullet, from this swing the vertical height the block has been raised is measured. The momentum of the block, plus the weight of the bullet embedded in it, must be equal to the momentum of the bullet before it struck the block ; or

$$MV = M_1V_1 + MV_1$$
$$MV = (M_1 + M)\ V_1$$
$$V = \frac{(M_1 + M)\ V_1}{M}$$

where M = weight of bullet
M_1 = weight of block
V = velocity of bullet
V_1 = velocity of block

V_1 can be obtained by means of the formula :—

$$V_1 = \sqrt{2gh}$$

where h denotes the vertical height in feet which the block was raised.

The method usually employed in ascertaining the velocity of projectiles is by means of an electric chronograph known as the Boulengé. An improved form of this instrument is the Bréger, which in theory and general arrangement is very similar to the Boulengé, and embodies all the improvements and modifications suggested by experience in using the latter instrument. Fig. 2 represents the Boulengé instrument, and what this apparatus registers, is the time taken for a projectile to travel over a measured distance (usually 150 or 180 ft.) in terms of the height in which a rod will fall under the influence of gravity in the same time.

Falling bodies have received much attention from eminent men for many generations. Galileo (1590—1640) proved that a body moving in a straight line with

constant acceleration, such as that produced by gravity, describes in any time from the commencement of the motion a distance proportional to that time. Again, Huygens in 1658 proved, by means of a pendulum, that a body descended vertically from rest in vacuo, in the latitude of Paris, 16·1 ft. in one second. And it has been proved by modern scientific men that bodies free to fall under gravity, follow the simple dynamic law :—

$$h' = \tfrac{1}{2} g t^2$$

h' = height fallen in feet
g = acceleration due to gravity = 32·2
t = time in falling.

As the chronograph is a gravity instrument, this law is the one governing the action of

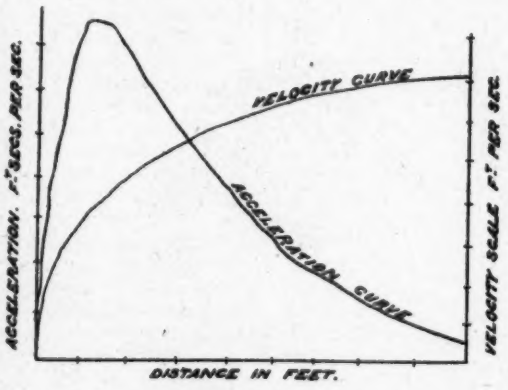


FIG. 1.—VELOCITY CURVE, ETC.

the apparatus. The theory of the instrument is as follows :—

Fig. 2 gives a view of the instrument ready to take the velocity of a shot. Two electric batteries (secondary batteries are preferred owing to their steady current) are employed and are connected up as shown in Fig. 3. The battery (A) is connected with the top electro-magnet A, and also with the first screen No. 1. The second battery (B) is connected with the lower electro-magnet B and with the screen No. 2.

When the current is switched on to the top electro-magnet A, it becomes energised and will hold the brass rod (chronometer) 22 ins. long, which is tipped with soft iron, in suspension. If the current be sent round the lower electro-magnet B, it also becomes energised, and will hold the small rod (registrar) 5 ins. long, in a similar way.

If the top e.-m. circuit be suddenly switched off, the chronometer-rod will commence to fall, but a short interval of time is required for the demagnetisation of the electro-magnet, sufficient to free the rod, the movement of the rod will therefore be delayed. Call this time (a.)

If the current from the B electro-magnet be switched off also, its rod will also commence to fall. The registrar will fall on a small trigger-plate, release a catch and a spring will start the circular knife (G, Fig. 2) forward. For each of these operations time is required, including, also, the time required for demagnetisation of the electro-magnet B; we will call the sum of these small times (b). If we contrive by means of a two-circuit switch to cut both electric circuits at precisely the same instant, both rods will fall, and when the longer one has fallen several inches, the shorter one will have reached the trigger-plate, started the knife and the knife will have struck the thin copper-tube, previously threaded over the long rod, the distance between the mark made and the zero (*i.e.* the point opposite knife edge when chronometer-rod was hanging) will form a constant for the instrument and will be the algebraic sum of times (a) and (b). In practice the switch is known as a disjunctor, and the constant for the instrument is 4·345 secs., this corresponds to a time ·15 secs. thus :—

$$h'' = \tfrac{1}{2} g t^2$$

$$4{\cdot}345'' = \frac{g t^2}{2}$$

$$\sqrt{\frac{2 \times 4{\cdot}345}{g \times 12}} = t = {\cdot}15 \text{ secs.}$$

It will be noticed, Fig. 3, that there are two screens used. The electric current, starting from the A battery,

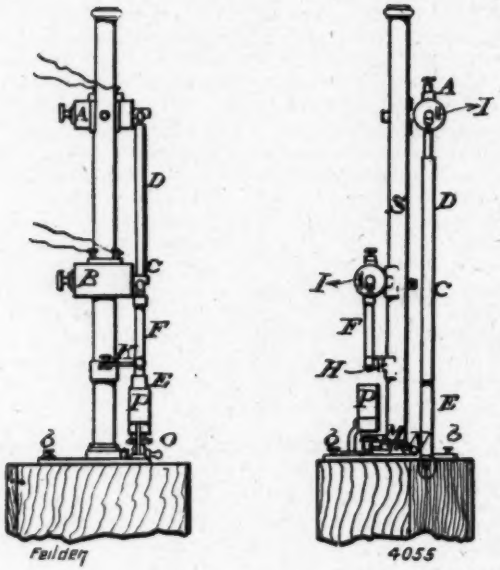


FIG. 2.—THE BOULENGÉ CHRONOGRAPH.

A Electro-magnet.
B " "
C Chronometer bar.
D, *E* Copper tubes threaded over bar *C*.
F Registrar bar.
G Circular-knife.
H, *K* Steadying bracket with adjustable screw.
I Indicators to show when current is flowing through electro-magnets.
P Holder to retain registrar after its fall.
M Trigger carrying knife.
N " spring.
bb Levelling screws.

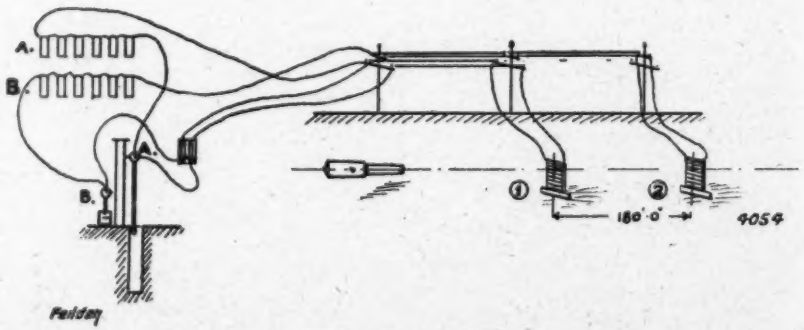


FIG. 3.—CONNECTIONS EMPLOYED FOR CHRONOGRAPH.

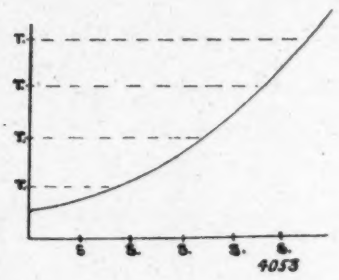


FIG. 4.

passes along the wire placed zig-zag fashion across the first screen and returns through the disjunctor, and the *A* electro-magnet of the chronograph. The *B* circuit takes the second screen and the *B* electro-magnet, passing through the disjunctor also: both circuits are insulated from each other When the gun is fired the projectile cuts the first screen, breaks the electric circuit, and the chronometer-rod falls; the projectile cuts the second screen in turn, breaks the electric circuit of *B* battery, and the registrar falls and releases the knife which makes a mark on the chronometer-tube while the latter is falling. The height of this mark is carefully measured by means of a specially constructed vernier, and the time taken for the instrument to operate is deducted (constant $h = 4{\cdot}345''$) thus giving a net height of fall of rod corresponding to the time taken for the projectile to traverse 180 ft. between the screens. The velocity thus obtained will be the average velocity between the two screens, the actual point where the shot possessed the calculated velocity being nearer the first screen, owing to the negative acceleration of the projectile due to the resistance of the air. In practice, however, as the retardation of the projectile due to the air, over so short a space would be very small, it is usual to take the observed velocity as the actual velocity at the middle point between the two screens. The next operation will be to reduce the observed velocity to muzzle velocity as the gun is placed some feet distance from the first screen (about 50 yards). The velocity obtained will therefore be at a point $\left(150 + \frac{180}{2}\right)$ ft. from the muzzle of the gun.

From experiments carried out by the Rev. Bashforth some few years ago it was proved that the retardation of a shot is some function of its velocity ($f V^3$) depending on the dimensions and weight of the projectile, and also on the form of its head. The resistance will also vary as the cross section or as the square of the diameter of a projectile

$$R \therefore \text{varies as } f V^3$$

where f is a quantity depending on special conditions, also

$$R \therefore \text{varies as } \frac{D^2}{W}$$

The Boulengé chronograph is not suited for measuring the resistance of the air to flight of projectiles, because the fewest number of screens for this is three, and so Mr. Bashforth invented a chronograph which bears his name and with which a dozen or more screens can be employed. Bashforth's experiments essentially recorded the times occupied by the shot in travelling through the series of screens placed at a certain and equal distance apart, so that if co-ordinates be taken and "times" and "spaces" plotted and a curve drawn through the intersections, we get a "graph" (*see* Fig. 4) of the negative acceleration of the shot due to the resistance of the air. The problem then is, to find the law of this curve in the form

$$t = f(s)$$

and thence to find

$$\frac{dt}{ds}$$

and finally

$$\frac{d^2t}{ds^2}.$$

Mr. Bashforth solved this problem by the method known as "Finite Differences" and constructed therefrom his well-known tables for reducing observed velocity to muzzle velocity, and which are universally employed.

It may be of interest to quote the calculations made by the writer in taking the

velocity of projectiles fired from a 14 Par gun quite recently. The screens were placed 150 ft. apart, and the gun was 90 ft. from first screen. The mean height of fall of chronometer was 11·559 ins. being the mean of six rounds.

$$\therefore\ h = \frac{gt^2}{2}$$

$$t^2 = \frac{h''}{193{\cdot}2} = \frac{11{\cdot}559''}{193{\cdot}2}$$

log. 11·559 = 1·0629203
" 193·2 = 2·2860071
" t^2 = $\bar{2}$·7769132
" t = $\bar{1}$.3884566
$\therefore t$ = ·24460

From this time the constant for the instrument (·15 secs.) has to be deducted.

·24460
·15
·09460

In this time the shot travelled 150 ft. between the screens, therefore the velocity

$$= \frac{150}{{\cdot}0946} = 1585{\cdot}7\ f.s.$$

From the muzzle to a point midway between the screens

$$= s = \frac{150}{2} + 90 = 165 \text{ ft.}$$

weight of projectile = 14 lbs.
diameter = 3"
velocity observed = 1585·7 *f.s.*

and applying Bashforth's formula

$$S_{muzzle} = S_{obs} + \frac{s}{C}$$

where $C = \frac{W}{cd^2}$ small c = ·9

being a constant for the ogival head of the projectile and for the density of the air.

$$C\ \therefore\ = \frac{14}{{\cdot}9 \times 9} = \frac{14}{8{\cdot}1} = 1{\cdot}73$$

and log. s = 2 2174839
" C = ·2380461
" $\frac{s}{C}$ = 1·9794368

$\therefore \frac{s}{C}$ = 95·3

$S_m = S_{obs} + 95{\cdot}3$

The observed velocity 1587·7 corresponds to 43541·1 in the tables

add 95·3
43636·4

which corresponds to a muzzle velocity of 1607 ft. per second.

Compressed Air and Bore-wells:

Their Application to Works of Public Water Supply.

By WILLIAM H. MAXWELL, A.M.Inst.C.E.

The use of compressed air as a means of power transmission has been the subject of considerable difference of opinion amongst engineers, but the concenience it affords as a means of conveying power to long distances is a matter of such immense industrial importance that it has become an efficient and powerful agent in the hands of the present-day engineer.

The subject opens up a wide field for useful and interesting investigation, and demands the careful study of the engineer in its application to the very numerous uses to which it may now be advantageously put. In the course of the present article one of these uses will be more particularly dealt with—viz., the application of compressed air to the raising of water for public supply, from deep bore-wells, a plant of this description having recently been installed under the author's supervision at the Corporation Waterworks of Tunbridge Wells.

Every engineer who has had experience in the use of the various available agents for the transmission of power, such, for example, as steam, electricity, air and water, will doubtless have learnt their comparative efficiencies and have proved for himself that compressed air, when compared with the use of steam direct (if consumed on the spot where generated), is low in this respect. Compressed air, however, has its own peculiar advantages, which operate in special cases, thereby making it not only the most economical agent under certain circumstances, but frequently the only possible one. Cases often arise, as in mining, tunnelling, &c., in which compressed air is the only power-agent capable of performing the services required, and where questions of economy are of secondary consideration.

Compressed air is the only general mode of transmitting power to great distances large enough to be measured in miles, and is the only one which is always possible, no matter how the power is to be distributed or applied. Its adaptability, too, to the utilisation of distant and otherwise unavailable sources of power render it a medium, the commercial importance of which can scarcely be over-estimated.

Considerations such as these led to the adoption of compressed air in the works above-named. Here it was found convenient to put down compressors at the pumping station, to supply them with steam from the existing boilers and so generate compressed air to be conveyed in a cast-iron main to two bore-wells 350 ft. deep situated about one-third of a mile distant, and to raise water therefrom to gravitate back to the reservoir and pump-wells at the main station.

The system is one which lends itself admirably to almost indefinite extension. Any number of wells may be put down in the surrounding country, within, say, a radius of 20 miles—the whole to be operated either individually or simultaneously from one central base by one staff. Thus, while the actual power cost of the air, or cost of fuel, per 1,000 gallons raised may exceed that of a separate steam-driven plant operating deep well pumps, there are many other items which go to make up the ultimate actual cost of the water obtained; and herein lie the advantages of a system of compressed air under circumstances similar to those described. All machinery may be centralised under one roof, and no work or buildings are required at the site of the well, beyond perhaps a single stand-pipe and rising main. At the outset, then, there is a saving in capital cost of the works. In working expenses the annual cost of supervision, labour, cartage of fuel to distant sites, repairs, rates and

taxes, and numerous other incidental charges inseparable from the running of separate stations, are avoided. Under such conditions it would certainly appear that compressed air is the most economical power agent to employ, and, all things considered, that it is the most efficient means of bringing together for public supply a number of deep well waters.

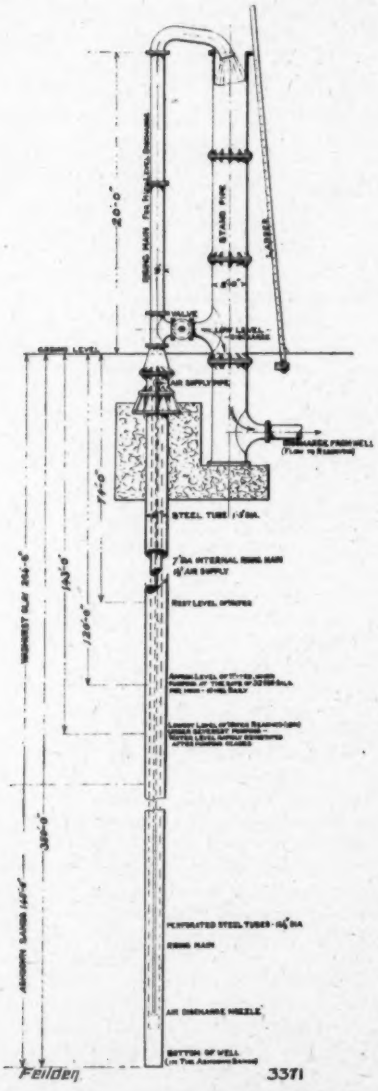


FIG. 1.—SECTION OF WELL, STAND-PIPE, COMPRESSED AIR-LIFT, ETC.

The compressor plant under description is situated in the engine-house, at a point close to the boiler-house supplying steam to the large forcing engines which deliver the town supply into high-service reservoirs through some two miles of rising main against a head, exclusive of friction, of about 350 ft. These boilers are of sufficient capacity to yield the additional quantity of steam required by the compressor engines, besides other machinery at the works.

The compressors, to which further reference will be made later, compress the air by two-stage compression, first to 25 lbs. per square inch, and then, after cooling, to from about 90 to 100 lbs. to the square inch (but varying according to the depth of water levels in the wells), and deliver it into a reservoir or large steel receiver communicating with the length of 4 in. air-main through which the air is conveyed to the wells. The connection and application of the air supply to the same are shown in detail in Figs. 1, 2 and 3.

PLANT AT THE BORE-WELLS.

The plant at the bore-wells consists of a rising-main, air supply pipes, stand-pipe, and various valves and connections, and is illustrated in Figs. 1, 2, 3, 4. Fig. 1 is a section of the well showing water-levels, rising-main, etc.

The well is sunk through the Wadhurst clay, which is over 200 ft. in thickness at this point, into the Ashdown sands, from which the supply of water is derived. The well is lined with steel tubes 15 ins. in diameter for its upper portion, and with perforated steel tubes 13½ ins. diameter below.

The method of boring and the various tools and plant used in the processes of sinking the well will be referred to in detail later.

The rest-level of the water, when no

pumping is being carried out, is 74 ft. below the ground surface, and the approximate level, when pumping at the rate of 32,000 gallons per hour for ten hours daily, is reduced to about 120 ft. below the surface. The lowest water-level reached under the severest pumping with the present plant is about 150 ft., and the level is rapidly reinstated after pumping ceases.

Inside the bore-well is hung a 7-in. diameter rising-main, as shown in Figs. 1 and 3, through which the flow of the well discharges. The air-supply pipe, which the author has enlarged from 1½ in. to 2½ ins. in diameter, is suspended from the top of the well and hangs centrally in the 7-in. rising main, delivering its air-supply through a distributing nozzle or outlet near the bottom of the well. The action of the high-pressure air on issuing through the nozzle is to mix with and lighten the water-column inside the 7-in. tube through which it ascends, driving the water with it. The air is used expansively in the bore-well, continually expanding as it rises nearer to the surface, the pressure, of course, gradually getting less, until atmospheric pressure is again reached at the ground surface.

The effect of enlarging the air-pipe as above-named was to reduce the high-pressure gauge from 105 to 91 lbs. per square inch, the latter pressure corresponding exactly with the water level in the wells, thus showing no back pressure losses.

In an air lift it is important to get suitable conditions as regards depth of immersion or head of water over the air nozzle. When the water levels in the wells are well maintained, as when recommencing to pump after a period of rest, the discharge obtained is very large, ranging from 25,000 galls. to 30,000 galls. per hour from one well (Fig. 5). The gradual lowering of the water levels naturally reduces the rate of discharge proportionally, but the quantity yielded from a bore-well compressed air-lift under suitable conditions is considerably in excess of that given by ordinary deep-well pumps in the same size bore-well. In an air-lift system there is the great advantage of having no complicated mechanism in the well itself, such as rods, pump-valves, or other working parts, which may get out of repair.

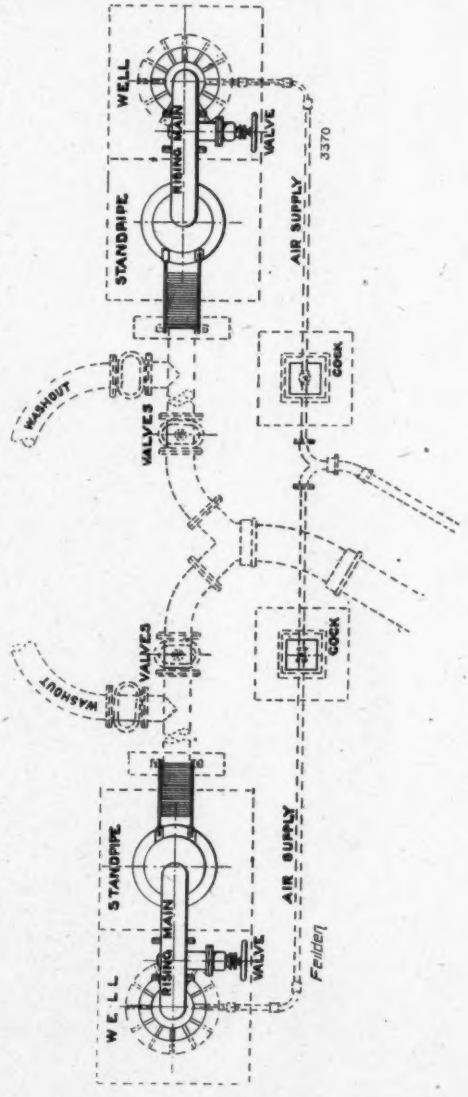


FIG. 2.—PLAN OF WATER COLUMNS, STAND-PIPES, AIR AND DISCHARGE PIPES.

The rising main is continued up to discharge into the top of a stand-pipe 20 ft. above the ground line to give sufficient "head" to deliver the water at the required elevation, or the discharge may be passed through the lower branch, near the ground-line, into the stand-pipe, if desired.

The effect of compressed air upon deep-well water is very beneficial to its use for public supply. It has the effect of aërating the water and hastening the precipitation of any iron that may be contained therein. It is also stated that in America, in cases where the capacity of wells have shown signs of decreasing, the application of the compressed air-lift thereto has resulted in increasing the volume of water flowing from the well.

Each compressor consists of one high-pressure steam cylinder, one low-pressure steam cylinder, one first stage and one second stage air-compressing cylinder, designed to be capable of delivering sufficient air to raise 16,000 gallons of water per hour from a varying depth of from 88 ft. to 150 ft. below the surface, to a tank or over a standpipe at a height of 20 ft. above the surface of the ground.

The high-pressure steam cylinder is 8 ins. diameter, and the low-pressure steam cylinder is 12 ins. diameter. The 1st stage air-compressing cylinder is of 10 ins. diameter, and the 2nd stage air-compressing cylinder is of 6 ins. diameter. The stroke of all is 14 ins.

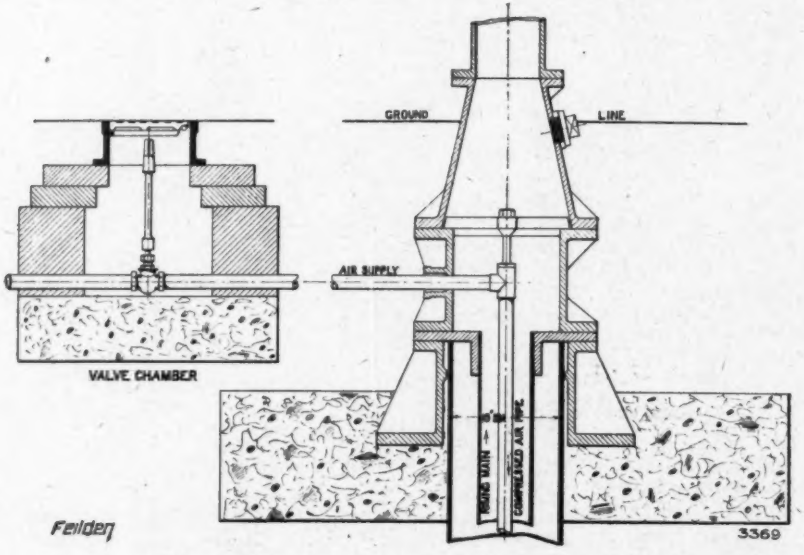


FIG. 3.—DETAIL AT TOP OF BORE-WELLS, SHOWING CONNECTION OF AIR SUPPLY.

THE HORIZONTAL COMPOUND STEAM ENGINES AND DOUBLE STAGE AIR COMPRESSORS.

Fig. 6 is a plan showing the general arrangement of the compressors, cooler, air pipes, etc., and Fig. 7 gives a view of the compressor engines.

The compressors were designed to give the greatest efficiency in steam consumption when the depth of water is from 100 ft. to 150 ft. below the surface of the ground.

The high-pressure steam cylinder, the high-pressure air cylinder, and guide bar, all are bolted tandem-wise to one bed-plate, and the low-pressure steam and low-

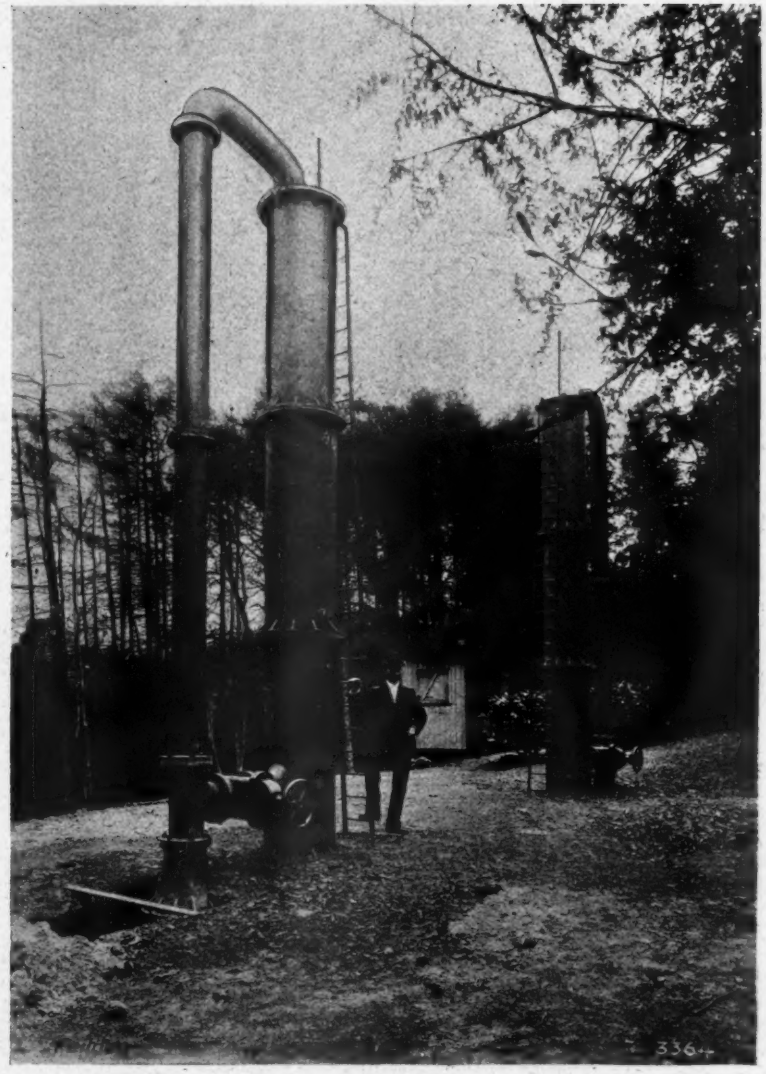


FIG. 4.—STAND-PIPE OF RISING MAIN AT THE BORE WELLS.

FIG. 5.—DISCHARGE OF COMPRESSED AIR LIFT AT THE BORE-WELLS.

pressure air cylinders are bolted to a second bedplate, one fly-wheel running in between the two bedplates.

The bedplate is of box section, 9 ins. deep, and has 3 ribs, 9 ins. deep, running the full length of the plates, two of which, forming the outside, have ample beading at bottom. The general thickness of metal is not less than $\frac{3}{4}$ in.

The bedplates are planed all over the bottom surface, the top surface being planed where needed to take cylinders, guide-bar, pedestals, and the necessary brackets.

In the air compressors both the first and the second stage air cylinders and the end covers are water-jacketed. The air is first compressed by the first-stage cylinder into an intermediate water-cooling vessel, from which it is drawn and further compressed to the full pressure required by the second-stage air cylinder. The piston-rod is connected to the tail-rod of the steam cylinder. The cylinder is of special close-grained cast-iron accurately bored to take pistons.

The compressor valves of all cylinders are of Messrs. Hughes & Lancaster's patent Corliss type, and operated by single eccentrics.

The specification provided that the arrangement of valves should be such that the following conditions should be obtained :—

(1) The valve to be opened and closed mechanically for suction to avoid any "wire drawing," and to make certain that the valve shall close at the right moment viz.,—at end of stroke of piston, to prevent any leakage or slip past the valve.

(2) The delivery valve to be shut mechanically to prevent slip, but to be

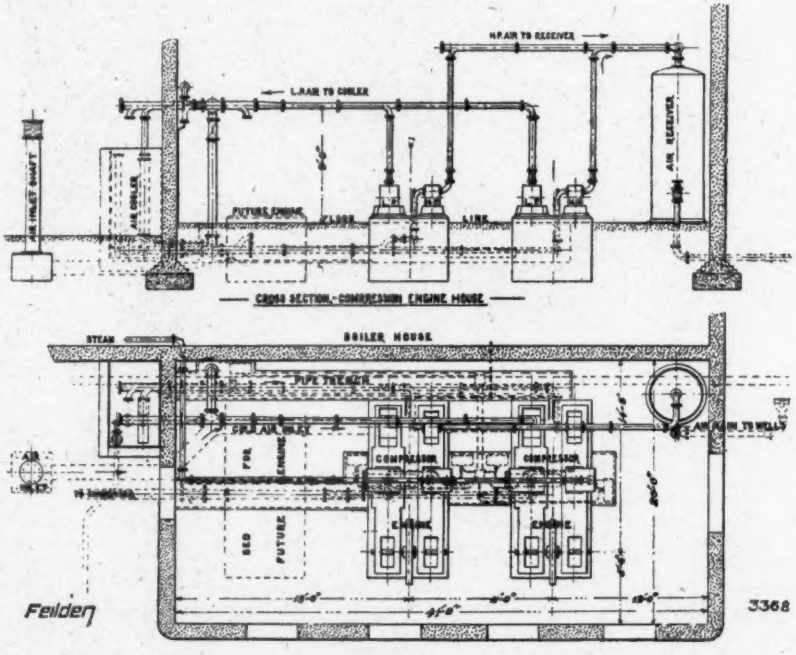


FIG. 6.—PLAN SHOWING ARRANGEMENT OF COMPRESSOR HOUSE WITH TWO COMPOUND STEAM AND STAGE AIR COMPRESSORS.

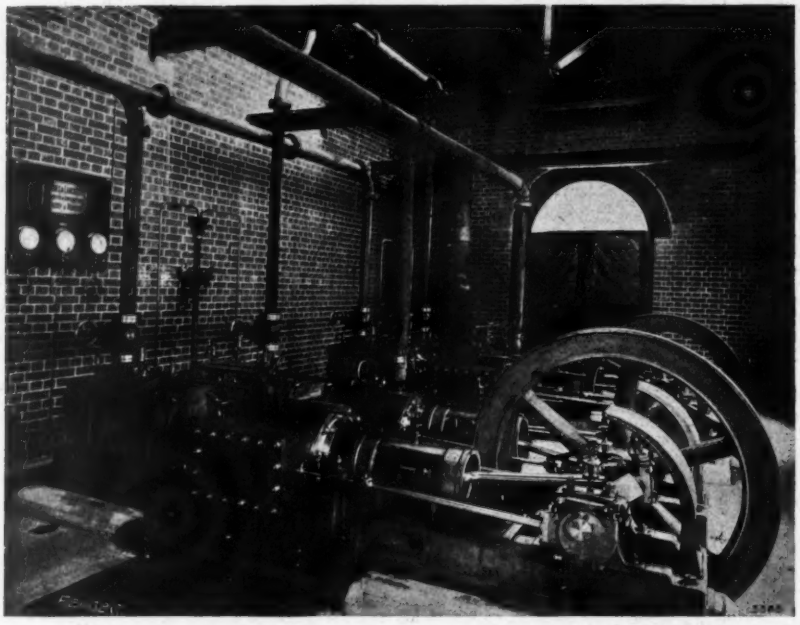


FIG. 7.—VIEW OF COMPRESSOR ENGINES.

opened automatically by the pressure in the cylinder. The delivery passages to be as small as possible consistently with keeping sufficient area.

(3) The clearance in the cylinder to be not more than 1 per cent. of the volume swept out by the piston. The air imprisoned in the Corliss valve to be returned to the cylinder during the compression stroke to prevent any further loss in volumetric efficiency.

(4) The valves to work without shock, and to be practically noiseless when running at the highest speed the compressors are likely to run at.

(5) The valves to be capable of being removed for inspection and replaced with the minimum loss of time.

(6) The driving gear to be so arranged that the valve can follow up its wear readily.

(7) The pressure on valve faces to be so balanced that there is no undue friction, and yet there shall be sufficient pressure to make a perfect joint between inlet and delivery passages.

(8) The barrel of cylinder and as much as possible of cover to be water-jacketed, but so arranged that they can be readily cleaned out in case any sediment should be deposited in water-jackets.

(9) The incoming air must not come in contact with any heated surface till it reaches the inlet air valve.

The steam cylinders are made of special close-grained cast-iron, accurately bored to take liners; the steam chests are the full length of cylinders and of ample width, the liners are of the very best close-grain cast-iron, free from blow-holes and accurately bored to fit pistons.

The space between liner and cylinder forms steam jacket and is about $\frac{3}{4}$ in.

The cylinders, end covers, and steam-chest covers, are lagged with fossil meal and sheet steel, and are provided by drain

cocks, tallow cups, and the necessary copper pipes, valve, etc., for connecting steam jackets to steam chest and steam traps. The drain cocks are connected by lever in such a manner that both can be operated by one movement. A sight feed lubricator is provided on steam branch to high-pressure steam cylinder.

The pistons are of cast-iron of good construction and fitted with broadcast iron spring rings.

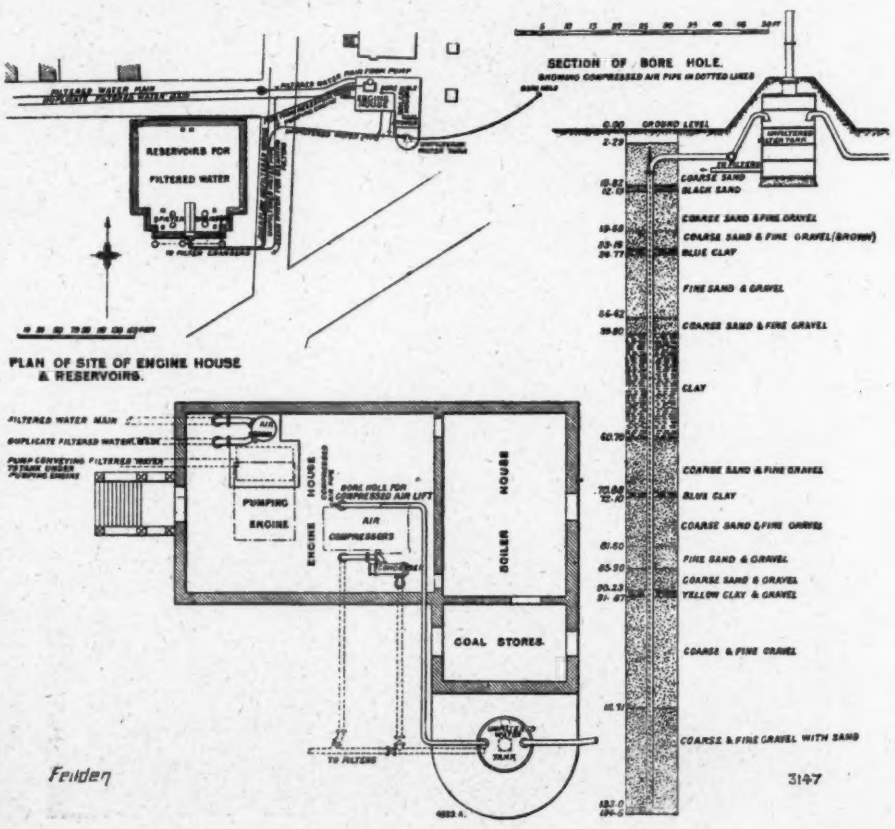
The piston-rod and valve-rods are of steel turned accurately to gauge.

The slide-valves of the high-pressure steam cylinders are on the Meyer cut-off expansion principle and are capable of being adjusted whilst the engine is running, so that the cut-off in the cylinder may be altered from quarter to three-quarter of the stroke. A pointer shows accurately on a scale the position of the cut-off.

The slide-valves of the low-pressure steam cylinders are of the ordinary "D" type.

The crosshead is of improved design, made of cast-steel, and fitted with adjustable cast-iron slippers top and bottom, having very large wearing surfaces.

The connecting-rod is of marine pattern,



FIGS 8, 9, 10.—DETAILS OF ARAD WATERWORKS.

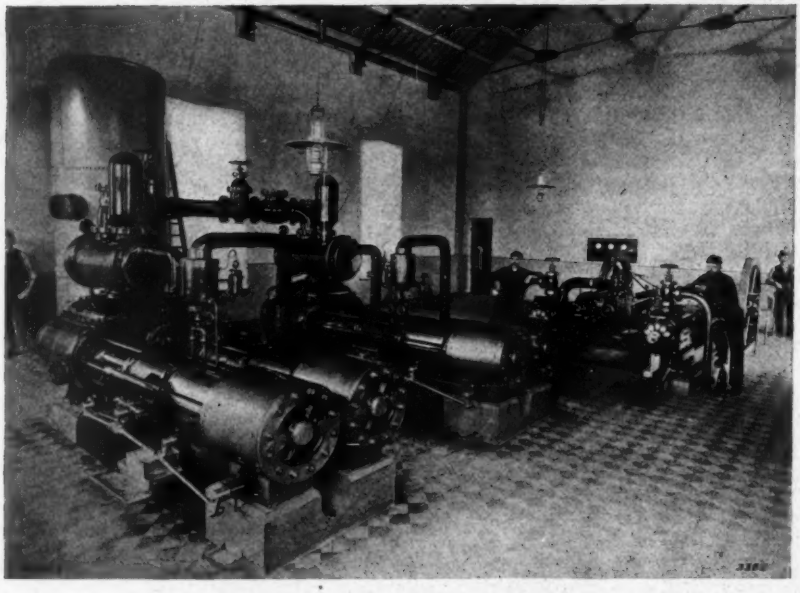


FIG. 11.—ARAD WATERWORKS: COMPRESSED AIR ENGINES.

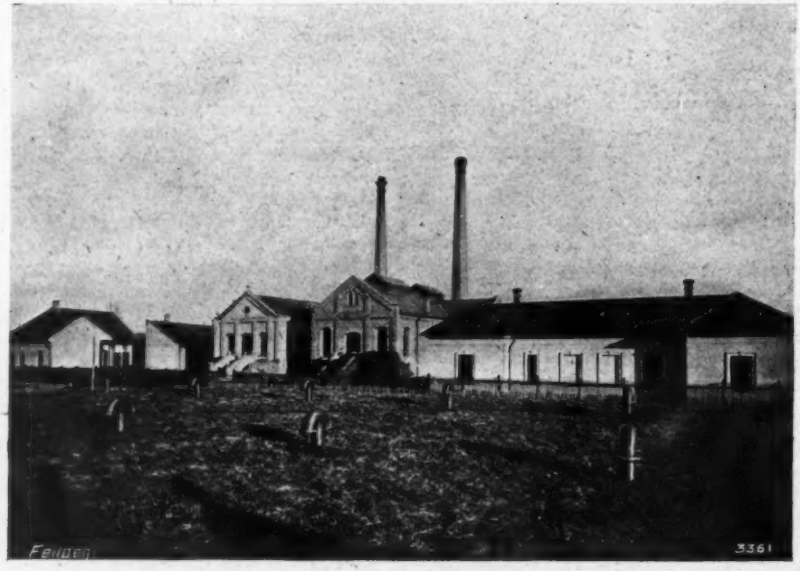


FIG. 12.—ARAD WATERWORKS: EXTERIOR OF BUILDINGS, FILTER BEDS, ETC.

is made of steel, and machined bright all over. The large end is fitted with gun-metal steps, having large wearing surfaces.

The eccentric straps and sheaves are of cast-iron, and the rods of mild steel finished bright all over. The straps are fitted with sight-feed lubrication arrangements.

The crank-shafts are of mild steel, finished bright all over, made in two pieces, and are accurately turned where required to fit plummer-blocks, connecting-rod brasses, fly-wheels, etc.

The fly-wheel is about 15 cwts., 5 ft. diameter by 4½ ins. wide, is turned on face and edges. It is keyed on to its crank-shaft by two keys.

The steam cylinder is provided with a screw-down stop valve of approved type.

The valve-rod glands are of gun metal, and the piston-rod glands are of cast-iron, bushed with gun metal.

The lubricating arrangements are such that the compressors can be run without stopping for a considerable length of time. All lubricators are of the siphon or sight-drop types; guide bars, crosshead pins, eccentrics, and main pedestals are lubricated by adjustable sight-drop lubricators.

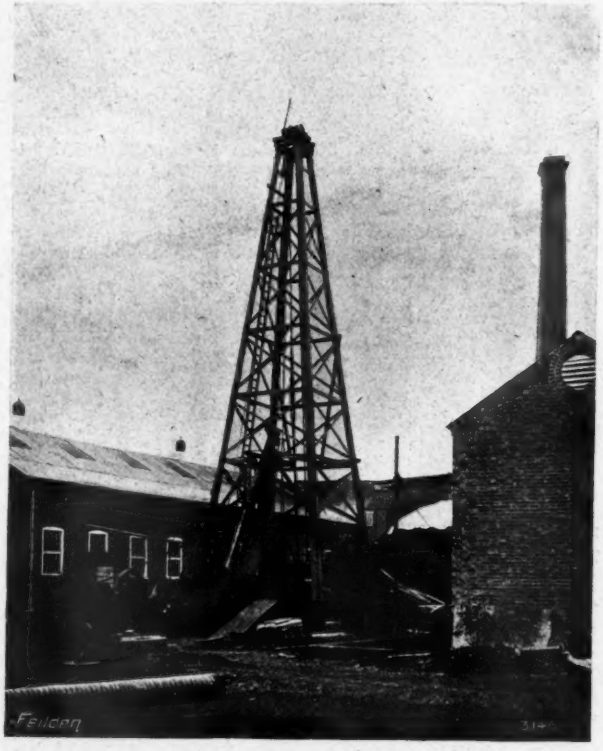


FIG. 13.—RIG BORING MACHINE BY MESSRS. MATHER AND PLATT, LTD.

The engines are neatly painted, and are provided with the requisite foundation bolts and plates, and a set of spanners.

In a test recently run 321,870 gallons of water were raised in 10¼ hours from one bore-well from a lift of 133 ft. A view of the discharge from one well is shown in Fig. 5. The makers of the plant were Messrs. Hughes & Lancaster, Engineers and Contractors, London and Ruabon.

COMPRESSED AIR-LIFT AT ARAD.

Another interesting example of air-lift is that at the Arad waterworks in Hungary, where there are two 9-in. boreholes each capable of delivering about 32,400 gals. per hour, only one of which, however, is usually in use at the same time, as this rate of delivery is found sufficient for the present needs of the town. The general arrangement of the compressors, air-lift and bore-holes is shown in Figs. 8, 9, 10.

From the section of the bore-well it will be seen that the water supply is obtained in the gravel stratum below an

impervious bed of clay about 20 ft. in thickness, the bottom of which is some 63 ft. below the ground surface.

The compressed air is carried down the bore-pipes by means of wrought-iron tubing, issues through a suitable nozzle, and raises the water into the cast-iron service well or unfiltered water-tank shown in the illustration.

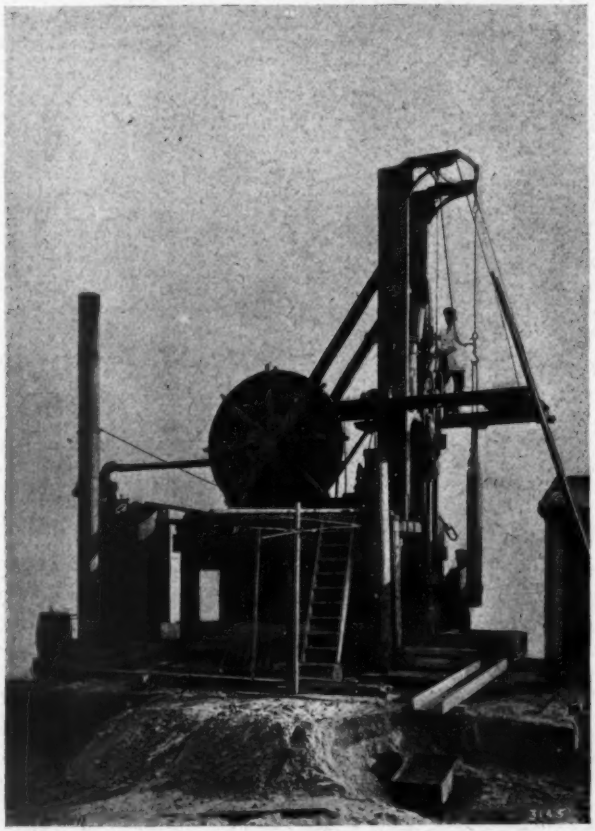


FIG. 14.—MESSRS. MATHER AND PLATT'S MACHINE FOR BORING.

The steam-engine air compressors (Fig. 11) for generating the air supply have compound steam-jacketed cylinders 11 ins. in diameter and 18 ins. stroke. The exhaust steam from the engine is carried to a surface condenser placed below the floor of the engine-house. The circulating water for the condenser is supplied by the pipe conveying the water from the service well to the filters.

There is an automatic arrangement in connection with the air-lift for intermittent working, as the supply of water reaching the well is insufficient for a constant flow. The water is cooled and aërated by the action of the compressed air. This plant also was laid down by Messrs. Hughes & Lancaster. Fig. 12 is an exterior view of the buildings and filter beds.

THE WALLASEY AIR LIFT.

To meet the growing needs of their district, the Wallasey Urban District Council recently found it necessary to utilise fully their existing available water sources, and decided to install an air-lift plant for raising water from the No. 1 bore-well at Poulton, being satisfied that a much larger quantity could be obtained therefrom than it was found possible to extract with the old deep-well pumps.

The air-lift plant was installed by the British American Well Works, of Queen Victoria Street, London, and consists of a set of horizontal combined engines and stage air-compressors, the steam engines being placed side by side and work tandem on

to the air-compressors. After leaving the low-pressure cylinder the air passes through an inter-cooler and then on to the high-pressure cylinder. Water-jackets surrounding the air-cylinders also cool the air during compression. The high-pressure air is led away through an air main to a receiver, and from there to the wells.

The Poulton well is of 10 inches diameter and 700 feet deep. The old pumping machinery was giving about 7,200 galls. per hour, and the makers of the air-lift undertook to increase this yield to about 32,000 an hour.

The system is in use at various breweries, public baths, and manufacturing establishments in various parts of the country.

BORE-WELLS.

Where suitable geological conditions obtain, the sinking of bore-wells to secure deep-seated waters is a useful means of largely augmenting the sources for purposes of public supply.

These wells are sunk in diameters varying from 3 inches up to about 45 inches, and to almost any required depth up to about 3,000 feet.* Two borings of the Wallasey Urban District Council, in addition to those already referred to, are each of 33 inches diameter, and 810 feet and 910 feet in depth respectively. These were sunk by Messrs. Mather & Platt, Limited, of Manchester. The same firm have put down, amongst many others, a boring at Lackenby (near Middlesboro') of 1,806 feet in depth, and two of large diameter (40 inches) at Rickmansworth.

Borings of this class are sunk by the aid of the "Rig Boring Machine" (Fig. 13), a plant made by Messrs. Mather & Platt, which comprises the requisite steam engine and hoisting gear, etc., all combined in such a manner that one man can control all the several working parts.

With this machine the boring is done by means of a round rope $2\frac{1}{2}$ inches diameter, at the end of which is suspended the jars, and the boring-bar and head into which is fitted from one to four chisels.

The up-and-down movement is obtained from the walking beam, whose motion is actuated by means of a crank driven from the engine driving the boring plant. The boring bar is turned round by the man on the surface, who moves it by means of a lever attached to the rope.

In the Mather & Platt machine, as illustrated in Fig. 14, a flat rope is used, and the up-and-down movement is performed by means of the steam pumping cylinder between the uprights of the machine; the boring bar turns round automatically by means of the ratchets on the top portion of the bar.

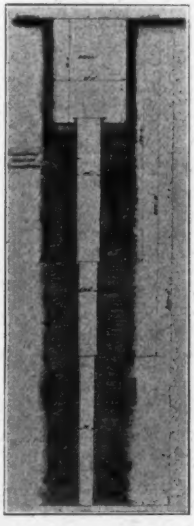


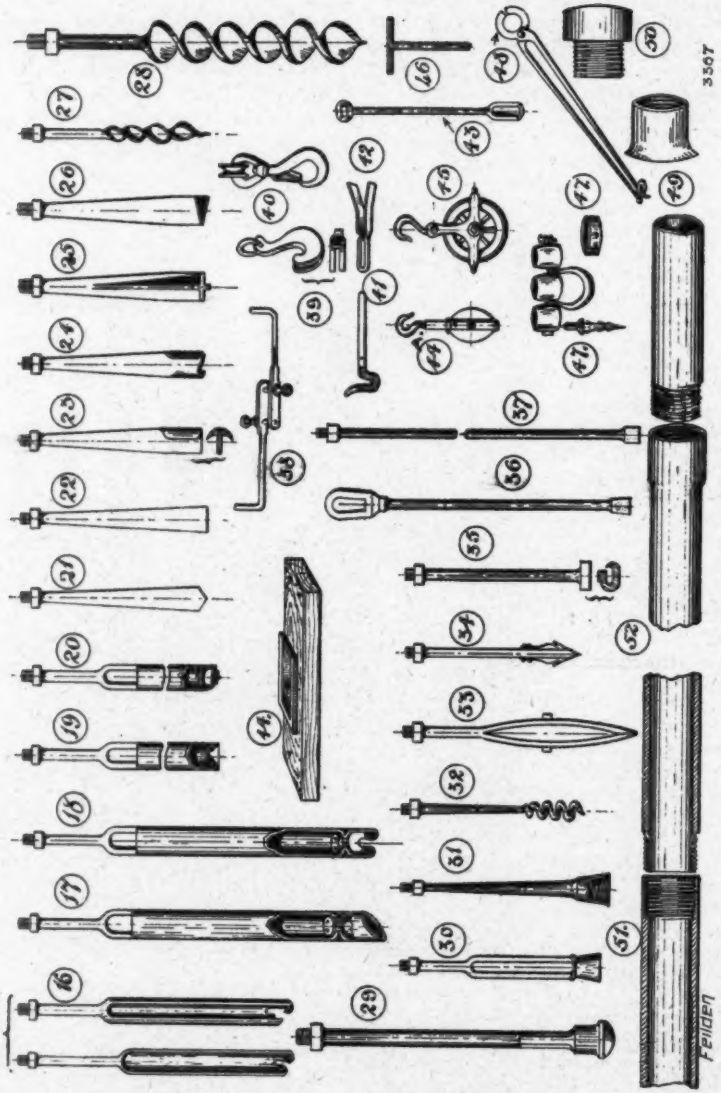
FIG. 15.—MODE OF PUTTING DOWN BORING.

With each type of boring machine, a similar type of sludge-pump is used for getting the *débris* out of the bore-hole.

The general principle of boring in hard rocks is the piercing or cutting a hole by continually repeated blows of sharp chisel-ended drills, or a number of such fixed in a metal block, a rotation being kept up so that no two blows in succession strike on the same spot.

In commencing operations a well or pit of about 8 ft. to 10 ft. diameter, see Fig. 15, is sunk to about 10 ft. or 12 ft.

* At Schladebach (Prussia), the deepest bore-hole in the world was put down, it having reached a total depth of 5,734 feet.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For names and descriptions see opposite page.
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deep, and the boring then put down at the centre. The boring tools are attached to iron rods, which are screwed together in 10-ft. lengths as the boring descends.

The various tools and plant employed in boring the wells we have had under consideration are of interesting variety, and have to be selected and changed from time to time according to the class of materials met with in the sinking of the bore. The under-mentioned are some of the principal tools used, as made by Messrs. J. Warner & Sons, of Cripplegate, with their various purposes assigned thereto (Figs. 16 to 52).

DETAILS OF TOOLS SHOWN ON PAGE OPPOSITE.

Fig. 16.—Shell Auger, for boring in clay and hard soils.

Fig. 17.—Shoe-nose Shell, with loose valve for boring in sand and loose soils.

Fig. 18.—Auger-nose Shell, with loose valve for boring in loamy sand.

Fig. 19.—Bell-mouth Shell, with loose valve for boring in shingle and coarse sand.

Fig. 20.—Auger Shell, with metal valve for boring in sharp sand or fine grit.

Fig. 21.—Diamond or Drill-Point Chisel, for boring in hard soils and sandstones.

Fig. 22.—Flat Chisel, for boring in flint or stone.

Fig. 23.—Tee Chisel, for boring in flint or stone.

Fig. 24.—S Chisel, for boring rocks.

Fig. 25.—X Chisel, for boring rocks.

Fig. 26.—V Chisel, for boring rocks.

Fig. 27.—Worm or Screw Auger, for boring soft stone.

Fig. 28.—Parallel Worm Auger, for boring chalk or marl.

Fig. 29.—Plug Drill, for clearing and straightening bore-holes.

Fig. 30.—Bell Box, with cleats, for withdrawing broken rods by passing over the swelled joints.

Fig. 31.—Bell Screw, for withdrawing rods by catching broken rod screws.

Fig. 32.—Spiral Worm or Miser, for withdrawing loose stones or broken rods from bore-pipes or holes.

Fig. 33.—Bow Dog, for lowering or raising bore pipes.

Fig. 34.—Spring Dart, with extra tongues for raising faulty pipes.

Fig. 35.—Crow's Foot, for extracting broken rods.

Fig. 36.—Swivel Rod, for turning the tools without twisting the rope.

Fig. 37.—Boring Rods, in 10-ft. lengths, with turned joints and universal male and female screws, made of

1	-in. sq. iron for 2-in. and 3-in. borings to 100 ft. deep.				
1¼	,,	,,	4-in. to 6-in.	,,	400 ,,
1½	,,	,,	7-in. to 8-in.	,,	600 ,,
1¾	,,	,,	9-in. to 10-in.	,,	1,000 ,,

Fig. 38.—Tillers or Levers, for turning rods.

Fig. 39.—Lifting Dogs, for raising or lowering rods.

Fig. 40.—Spring Hook, for attaching to rope for lifting purposes.

Fig. 41.—Rod Wrenches or Hand Dogs, for screwing and unscrewing rods.

Fig. 42.—Scotches, for holding up rods over and on boring boards whilst being screwed together or being disconnected.

Fig. 43.—Auger Cleaner, for removing clay, marl, or chalk from augers.

Fig. 44.—Auger Boring Board, for resting and guiding tools for cleaning, connecting, or examination.

Fig. 44A.—Snatch Block, for lifting rope.

Fig. 45.—Rope Pulley, for lifting rope.

Fig. 46.—Tee Screwdriver, for varied purposes among tools.

Fig. 47.—Shear-Leg Fittings, for connecting and binding ends of legs.

Fig. 48.—Pipe Tongs, for making joints.

Fig. 49.—Steel Pipe Shoes, for protecting and sharpening cutting edge of pipes.

Fig. 50.—Cast-iron Screwed Driving Cap.

Fig. 51.—Flush Screwed-Joint Bore Tubes of welded wrought-iron, made in 6-ft., 8-ft., or 10-ft. lengths, with lapped joints.

Fig. 52.—Swelled-Joint Bore Tubes of welded wrought-iron, made in 6-ft., 8-ft., or 10-ft. lengths, with lapped joints.

A complete set of boring tools suitable for boring to 800 ft. or 1000 ft. deep, with the necessary strong 1½-inch boring rods with turned screwed joints, may be obtained at a cost of about £200.

Figs. 53 and 54 illustrate a borehole and testing plant put down into the chalk by Messrs. Isler & Co., at the Kent Waterworks, Overy Street, Deptford. The views show the portable steam-engine, air compressors, and discharge from the well, during test, at the rate of 60,000 galls. per hour.

An overflowing artesian well bored by Messrs. Isler & Co., at Bourne, Lincolnshire, is shown in Fig 55, with a discharge or overflow at the rate of 3,480 galls. per minute. The figure also illustrates the plant and general operations of boring.

An interesting example of an artesian well sunk through the oolitic strata in 1856, in this district, yielded about half a million gallons of water per day under a pressure sufficient to supply the town without the aid of pumping power.

In the earlier portion of the present article particulars were given of the raising of water from deep bore-wells by means of a compressed air lift; at the site of the same works there are also two bore-wells fitted with steam-driven deep-well pumps of the type shown in Fig. 56.

FIG. 53.—BORING PLANT: PUMPING WITH AIR-LIFT AT OVERY STREET, DEPTFORD, AT THE RATE OF 60,000 GALLONS PER HOUR. KENT WATERWORKS CO.

The bucket and suction valves are placed at a depth of about 203 ft. below the engine-house floor in a gun-metal pump barrel 4 ft. 9¼ in. in length and 8½ ins. diameter. The plant, running at 27 revolutions per minute, delivers about 16,000 gallons of water per hour. The pumps were installed by the well-known

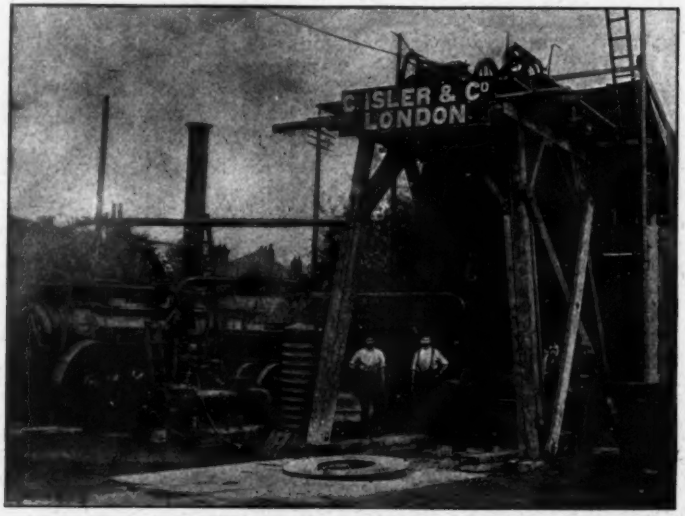


FIG. 54.—KENT WATERWORKS: VIEW OF BORING AND COMPRESSED AIR TESTING PLANT.

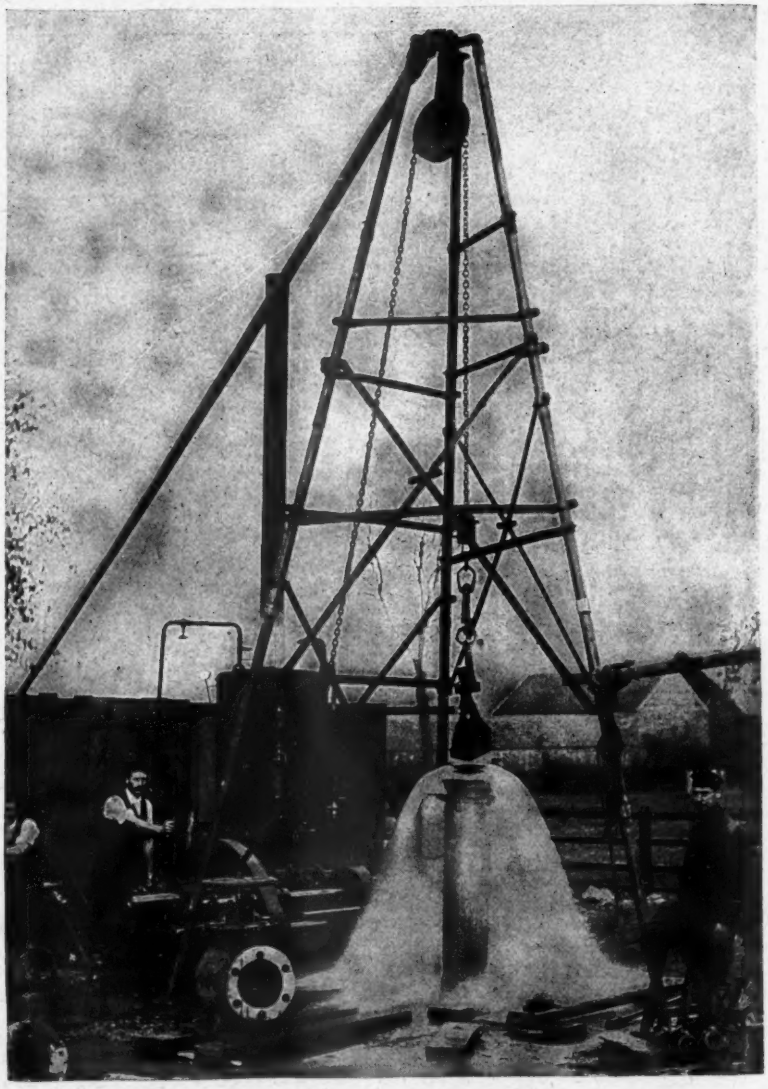


FIG. 55.—OVERFLOW FROM ARTESIAN BORING.

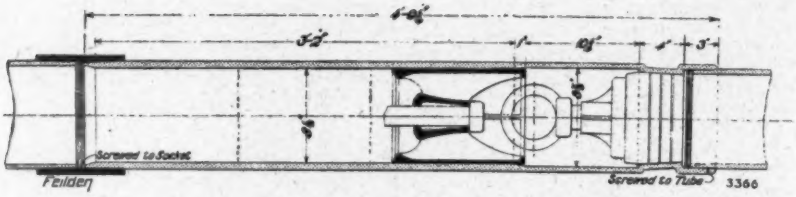
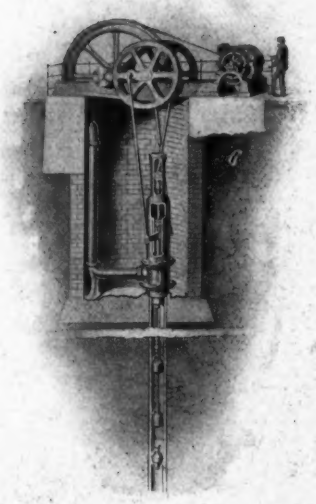


FIG. 56.—DETAILS OF PUMP BARREL OF DEEP-WELL PUMP.



FIF. 57.—MESSRS. MATHER AND PLATT'S DOUBLE-ACTING WELL PUMP.

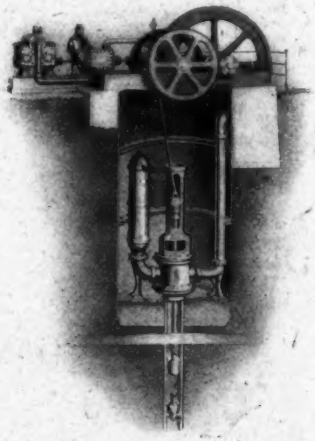


FIG. 58.—MESSRS. MATHER AND PLATT'S SINGLE-ACTING WELL PUMP.

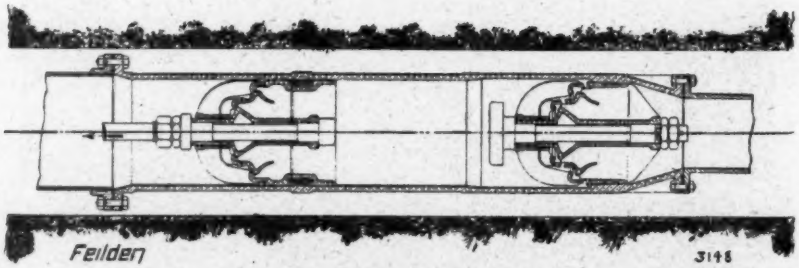


FIG. 59.—MESSRS. MATHER AND PLATT'S DEEP-WELL PUMP.

firm of Messrs. James Simpson & Co., Ltd., of Pimlico, and have been working for about six years with every satisfaction.

Messrs. Mather & Platt's double-acting and single-acting deep well pumps are shown in Figs. 57 and 58 respectively. The pump-barrel can be placed at any required depth in the bore-hole to suit the water level, and the pumps are suitable for driving either by electric motor or steam.

The working barrel, showing Cornish bucket and bottom clack for an 18-in. single-acting pump of 4 ft. stroke, is illustrated in detail in the accompanying Fig. 59. On the upward stroke of the bucket when lifting water the valves are closed, and the valves of the bottom clack are open. On the downward stroke of the bucket the reverse is obtained.

Underground water may be obtained from borings in the manner above indicated at a cost of about 4d. per 1,000 galls., including pumping and repayment of capital, interest, etc.

The principal water-bearing formations for wells are the chalk, the lower green sand, the triassic sandstone (especially the Bunter series), the oolite, Permian, and the millstone grit.

Laundry Engineering.

By F. J. ROWAN, A.M.Inst.C.E.

THE steam laundry is a direct product of modern civilisation, and in several ways bears testimony to the far-reaching application of engineering science, which formed one of the distinguishing features of the nineteenth century.

Considering the comparatively recent date at which the first attempts were made to introduce washing machines worked by hand, the present state of development to which laundry engineering has attained gives convincing proof of the rapid growth of this branch of industry. Not only do we find a great variety of machines in use, and their construction affording employment to the establishments of about thirty or forty engineering concerns in this country alone, but also many interesting engineering problems or questions are found to be involved in this application of machinery. It affords, in fact, another illustration of the wide variety of ways in which engineering science ministers to the convenience of mankind. The tendency of what is called "modern civilisation" is towards the congregation of numbers in towns and cities; and hence we have large hotels, large hospitals, prisons, asylums; whilst large railways and steamships attest the restless spirit of the age, so that everything has to be done in bulk and quickly—even hurriedly. The primitive and homely method of washing by hand (and sometimes by the use of the feet, as in treading blankets, etc.) with starching and ironing also done by manual labour, could not cope in speed with the demands of these latter days; and consequently we find that machinery driven by power has displaced old methods. Hand labour can deal with one or at most a few articles at a time, whilst machinery deals with many. Increase of speed in these operations often meant, and still means, a much more rapid destruction of the articles or fabrics dealt with, and the average householder has in the past looked upon the steam laundry as anything but a desirable outcome of modern civilisation. It has, in fact, often been made the butt of ridicule or sarcasm; being represented as a ruthless destroying fiend, or as supplying an ordeal for strength and durability that might be used for testing shot-proof armour. To some the acme of grim humour seems to have been reached when the steam-laundry, which has worn a shirt almost to shreds, quietly refuses to receive it for washing and dressing, as it does not choose to take the responsibility of its destruction! Nevertheless, people seem to have concluded that the greater expedition of the steam laundry system counterbalances the destructive effects of the mechanical appliances which it substitutes for the gentler treatment of hand labour. That being so, it must be the aim of the skill which is directed towards this department of engineering to reduce to a minimum the destructive effects while preserving the maximum rate of carrying out the necessary operations.

Whether we adopt the point of view of the maker of laundry machinery, or take that of the user, a general survey of the subject of laundry engineering cannot but convince us that, in spite of its apparently simple processes, it calls for no mean measure of technical knowledge and skill. It embraces the chemical, the mechanical, and the electrical departments of the science of engineering, and provides questions and problems in all these departments which are not to be settled by mere tyros.

Allied questions, demanding administrative and actuarial ability, also come into view here as in many other matters of business. To give an idea of what is involved in a knowledge of laundry engineering (in which term are included both use and construction of the steam laundry) we enumerate the following subjects, all of which present questions for the consideration of the laundry engineer :—

Systems of marking the various articles to be dealt with.
Arrangements for sorting different qualities, etc., and distributing them in the laundry.
Disinfection — its processes and apparatus.
Soaps and bleaching chemicals—their use and effects.
Water, and the various methods of softening and purifying it.
The removal of stains, and "dry" and wet cleaning.
The washing and general treatment of different fabrics and materials.
Various methods of drying, and apparatus therefor.
The plenum and vacuum systems in ventilation of drying closets and main buildings.
The treatment of boilers, and the economical use of fuel.
The treatment of engines, and the economical use of steam.
The application of exhaust steam to boiling, and to heating air for drying and ventilation.
The processes of blueing, starching, and glazing.
The processes of ironing and mangling, and the like.
Electric driving and electric lighting.
Other systems of lighting.
The design and care of machines, and their proper use.
Vans and hampers for horse or motor collection and delivery.

It is not our intention in this series of articles to take up that list of subjects—we shall confine ourselves to descriptions and illustrations of buildings and machines of a variety of designs. It will, however, be apparent that we must make some reference to many of these subjects in describing the machinery with which they are associated. We propose to deal with the following special points : — The buildings required for a steam laundry, and their arrangement ; soaking tubs and vats ; washing machines, hand and steam-driven, for hot water and cold water, for different classes of fabrics ; disinfecting and boiling apparatus ; wringers, and their use ; centrifugal machines (or hydro-extractors) for drying ; drying closets ; vertical and horizontal racks for drawing out ; heating and ventilating apparatus ; starching machines ; ironing, mangling, goffering and fluting machines.

It will be admitted that, taking all the branches of our subject collectively, there is material for at least two volumes, if anything like an exhaustive treatise were attempted.

The interest attaching to this, at present, perhaps, the youngest branch of engineering is, however, so great, and the variety of its machinery is so extensive, that a short notice of its products will be fully justified.

The question of laundry finance, or whether steam laundries offer a profitable branch of industry, does not properly enter into the scope of such articles as the present. It is, nevertheless, almost impossible wholly to exclude it, because it is to a great extent the deciding factor in the inquiry as to whether hand-power or steam-power for laundries will survive. The small returns often derived from laundry companies are, no doubt, due to over capitalisation in many cases, though inefficient management has its own share in the result frequently. Washing for large hotels, hospitals, asylums, institutions, steamship companies, and the like, is a fairly steady and regular business (and these are the cases in which the greatest speed of work is demanded), but the heterogeneous trade obtained from the public generally is more or less precarious ; and as profits can be derived only from payments for work done, this business offers a striking instance in which small capital charges and efficient management are vital to its prosperity. Very few statements have been published showing

the cost of the various operations of a laundry and the profits to be realised, but the following table was given by the *Laundry Journal*, the editor of which vouches its value :—

This table shows an average possible profit of over 30 per cent., and if anything like that is earned on a moderate capital the result cannot be very far from being satisfactory.

Table showing cost of Laundry Work, including collection and delivery, with net profit on each item.

Price Charged for Work.	Class of Goods.	Cost of Washing.	Cost of Ironing.	Cost of Collection, Office, Fuel, Material, Rent, Taxes, Gas, Water, and Total Upkeep.	Prime Cost.	Net Profit.
		Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
4d. each.	Shirts	12½	37½	27½	77½	22½
1s. per dozen.	Collars	5	25	27½	57½	42½
4d. each.	Servants' Dresses	20	50	27½	97½	2½
1s. per pair.	Curtains	12½	12½	27½	52½	47½
2d. each.	Muslin Aprons	12½	50	27½	90	10
2d. Underclothing. 3d., 4d., 6d. N.dress.	Body Clothes	12½	27½	27½	67½	32½
2d. Sheets, 2d., 3d. Cloths, all flat work, 1d.	Household	22½	25	27½	75	25
4d. per yard Linen.	Large Table Linen	15	30	27½	72½	27½
1s. each.	W. Counterpanes	25	20	27½	72½	27½
6d. and 8d.	C. Counterpanes	12½	12½	27½	52½	47½
2d. each.	Flannels	10	25	27½	62½	37½
8d. per pair.	F. Trousers	10	20	27½	57½	42½
6d. each.	W. Waistcoats	7½	33½	27½	68½	31½
Average Profit on	General Fancy Work	...	...	...	...	40

(To be continued.)

Fred. Geo. Rowan

The Connections of Switchgears for Electric Light and Power Purposes.

By W. E. WARRILOW.

(Concluded from page 447.)

❀ ❀ ❀

BEFORE considering the connections of gears under the second class, the boards illustrated in Figs. 8 and 9 are worthy of attention. They represent the front and back of a three-phase extra high-tension generator board. The chief feature is the arrangement of the switches at the top of the gear, this position being chosen as the safest, by reason of the arc produced when the switches are opened under load. Breaking as they do in air, an exceptional distance must be allowed to ensure safe opening of the circuit, while the arc is confined to the space formed by the marble division slabs. The arrangement of the connections at the rear can be readily, gathered from Fig. 9, in which the bus-bars, resistances and transformers can be seen.

Turning now to Class 2, a distinct difference in design will be noticeable, the aim in view being neatness in arranging, economy of space, and abolition of straggling connections.

Fig. 10 is a diagram of the connections needed for a combined lighting and traction station on the direct-current system. For the dynamos the necessary gear comprises wattmeter, fuse, reverse-

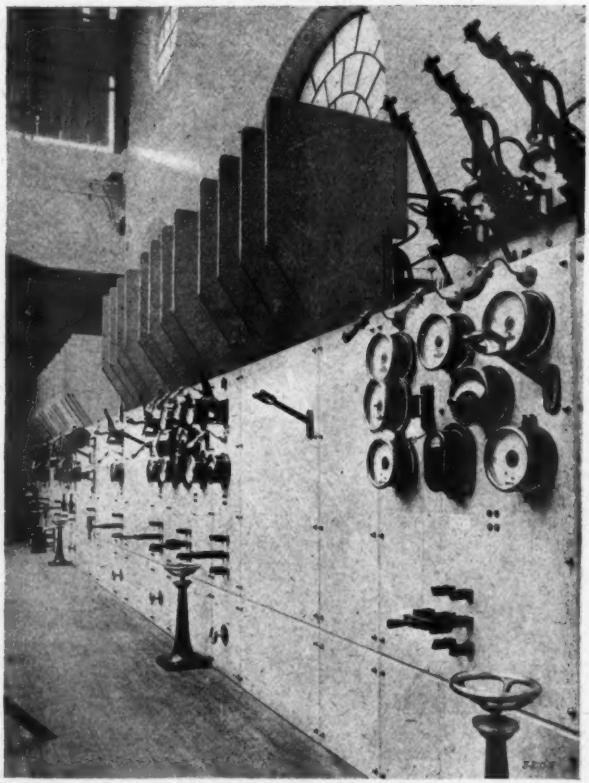


FIG. 8.—EXTRA HIGH-TENSION GENERATOR BOARD, FRON VIEW.

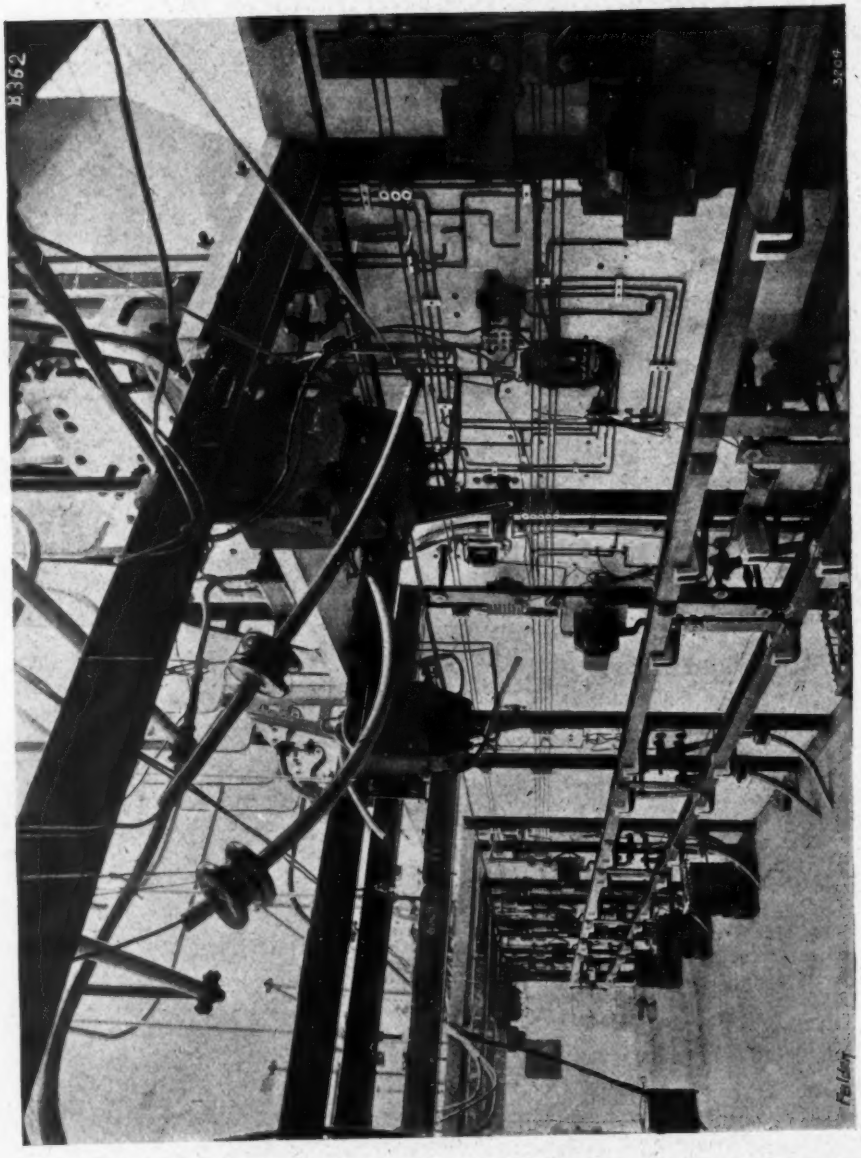


FIG. 9.—EXTRA HIGH-TENSION GENERATOR BOARD: BACK VIEW.

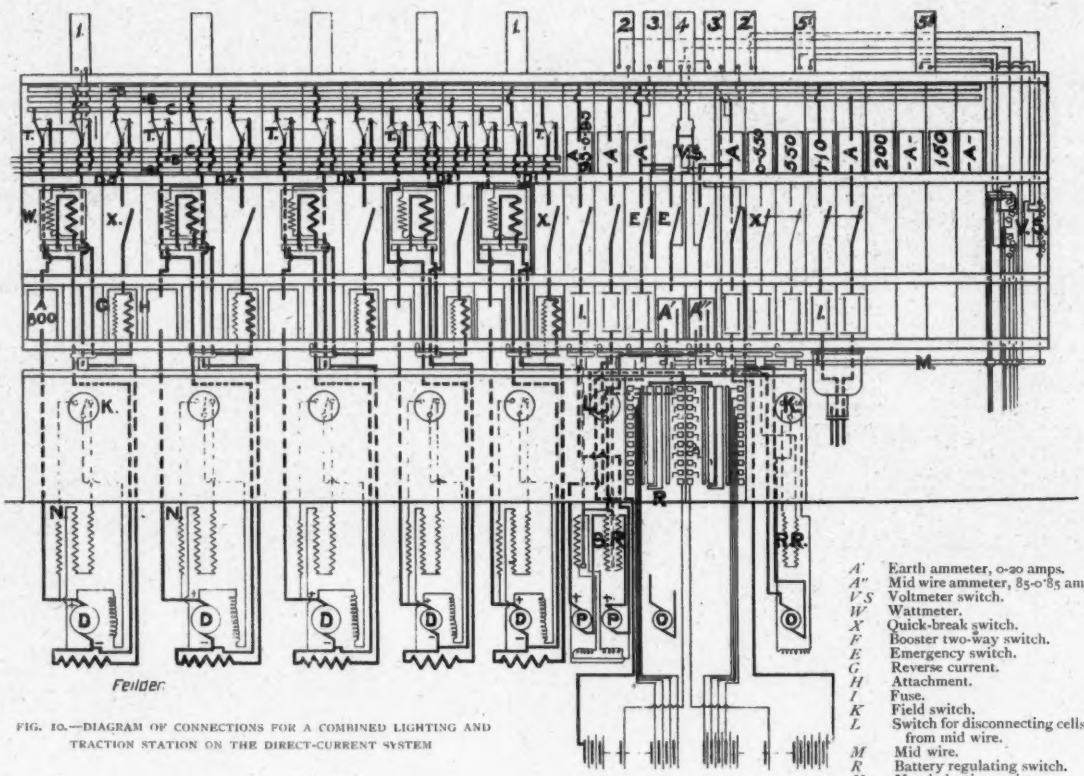


FIG. 10.—DIAGRAM OF CONNECTIONS FOR A COMBINED LIGHTING AND TRACTION STATION ON THE DIRECT-CURRENT SYSTEM

1 450-550 volts (machine).
2 220-280 volts (− and mid wire).
2′ 220-280 volts (+ and mid wire).
3 220-360 volts (− battery, mid wire).
3′ 220-360 volts (+ battery, mid wire).
4 0-115 volts (Booster).
5 210-250 volts (feeder 1 and 2).
B (+ and −) + and − bus-bars.

C Equaliser.
T Triple-pole throw-over switches.
D 1-5 Dynamos 1-5.
A Ammeter.

A′ Earth ammeter, 0-20 amps.
A″ Mid wire ammeter, 85-0-85 amps.
V S Voltmeter switch.
W Wattmeter.
X Quick-break switch.
F Booster two-way switch.
E Emergency switch.
G Reverse current.
H Attachment.
I Fuse.
K Field switch.
L Switch for disconnecting cells from mid wire.
M Mid wire.
R Battery regulating switch.
N Non-inductive resistance.
S R Starting resistance.
R R Regulating resistance.
O Booster.
P Balancer.

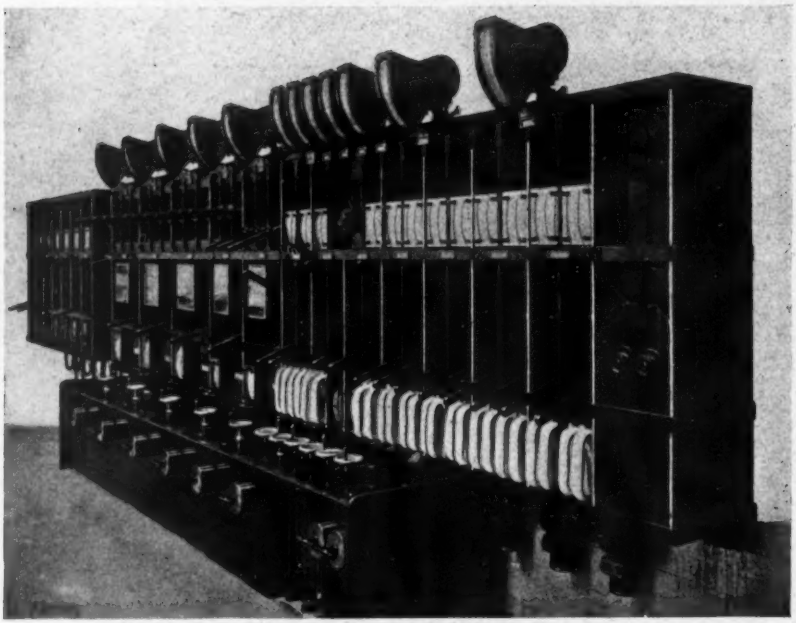


FIG. 11.—SWITCHBOARD FOR COMBINED LIGHTING AND TRACTION STATION: DIRECT-CURRENT SYSTEM.

current circuit-breaker, ammeter, voltmeter, and throw-over switch, as well as field rheostat and field-breaking switch. The lighting feeders require the above, with the exception of the field arrangements and wattmeter, the reverse-current cut-out also giving place to a quick-break switch. The traction-feeders need similar fittings to the above, though here the quick-break switch is replaced by a maximum-current circuit-breaker. Balancer and booster starting switches, an accumulator charge and discharge switch, and pilot voltmeter switches complete the requirements of this particular case.

Fig. 11 represents the embodiment of the above connections in actual practice. The entire gear is made up of a number of cells or compartments formed by horizontal slates grouted into the wall, and vertical division slates resting on the horizontal slates, which are grooved for the purpose. The slates comprise the framework of the gear, the vertical slates being easily removed for inspecting the panels, while the horizontal slates, fixed into the wall, are arranged to receive the several fittings which make up the connections between the various portions of the board. These fittings are secured by a special cement into porcelain insulators, the latter in turn being fixed into the slate by a similar method. By this means the connecting links between cell and cell are sound mechanical couplings, and not only that, but their rigidity enables them to be used to carry the moving parts of the switches, also ammeter and fuse contacts.

The entrance of the cable is effected below the bottom slate, to which is attached a cable receiver or shell. Inside this the conductor is sweated to its particular terminal, according to the size and character of the cable. Directly above the cable receiver is the fuse cell, containing

duplicate contacts for the insertion of two fuses. Above this in exact alignment is the switch compartment, surmounting which is the ammeter cell. The top side of the uppermost slate of the frame carries a bus-bar fitting, to which can be attached either a link or a casting, having from one up to four holes in it. The entire board is surmounted by a slate which holds the voltmeters and synchronisers when the latter are required. It will be readily understood that a greater number of panels can be fitted to form a complete gear, and that very little space will be taken up either vertically or horizontally. Referring to the photograph; the machines occupy the centre of the gear, while on either side are arranged the lighting and feeder panels. The dynamo currents pass through an ammeter, wattmeter, reverse-current cut-out and quick-break switch on one pole, and on the other they flow direct to the change-over switch, a third cable being also brought up to carry the equalising current. The reverse-current attachment is mounted directly below the quick-break switch, which it is arranged to release when current returns from the bus-bars into the machine. The wattmeters are fitted in the same line of cells as the switches, and they can be removed after introducing a short-circuiting plug provided in the panel. The bus-bars, both lighting and traction, surmount the slate-frames which carry their entire weight. They are made up of copper bars laid in "asbestonite" channels, the spring clips for making contact with the throw-over switches being fastened securely to their respective bars. The moving arm of the switch is hinged to the fitting supplying the machine current from below, so by this means the dynamo can be made to supply either set of bus-bars by merely moving the switch. The bars are carried to the right and left of the board over their respective circuits (either lighting or traction), which they supply through ammeter switch and fuse on the lighting board and ammeter and circuit-breaker on the traction board. Kicking coils and lightning arresters are also fitted to these latter panels.

Below the machine-board is fixed the regulating table carrying the rheostat handwheel and field-breaking switch, the resistance frame for the former being mounted directly below the panel either on the floor or girders projecting from the wall. The side view in Fig. 12 shows the bus-bars, throw-over switch and panels fitted below with switch and automatic attachment.

Between the machine and lighting-feeder panels are the balancer and booster panels, the former having switch ammeter and fuse on each pole, and the latter ammeter, two-way switch and fuse. The two-way switch provides for the charging of the cells through the booster on the one contact, and on the other the discharging of the accumulators, the booster being cut out of circuit.

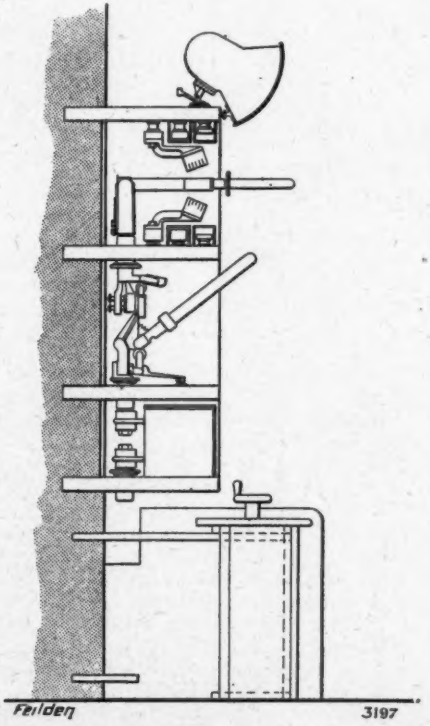


FIG. 12.—SIDE VIEW OF COMBINED BOARD, SHOWING BUS-BARS, THROW-OVER SWITCH, ETC.

Below the balancer-panels are the starting and regulating resistances, the handwheels of the former having an indicating device fitted to them, to enable the switchman to see when he has all the resistance in or out. This is of great importance, as the closing of the balancer-switch with the starting resistance all out would be fraught with serious consequences.

Adjoining the above handwheels are the battery regulating-switches, these being arranged to occupy a very small compass. They are also provided with an indicating device, which shows the number of cells in circuit. The booster regulating rheostat handwheels are fixed to the right of the accumulator-switches, and on the front slate of the table the booster field switches are mounted. A similar switch to these latter is fastened to the machine regulating table on the extreme right, this switch being used to disconnect the cells from the middle wire. The earth leakage is registered on an ammeter for that purpose, in a panel directly above the accumulator-switches, and adjoining this ammeter, is a similar instrument for the mid-wire currents. The extreme right of the board is taken up by a multiple-contact switch for obtaining the voltage at a distant point on any of the lighting feeders. The traction feeders have an ammeter, circuit-breaker, lightning arrester and kicking coil on the positive pole only, the negative cables being clamped direct to the bus-bar, in the space between the traction and machine boards. The machine and feeder voltmeters are mounted on the top of the board, the instruments presenting their scales so as to be readily seen from below.

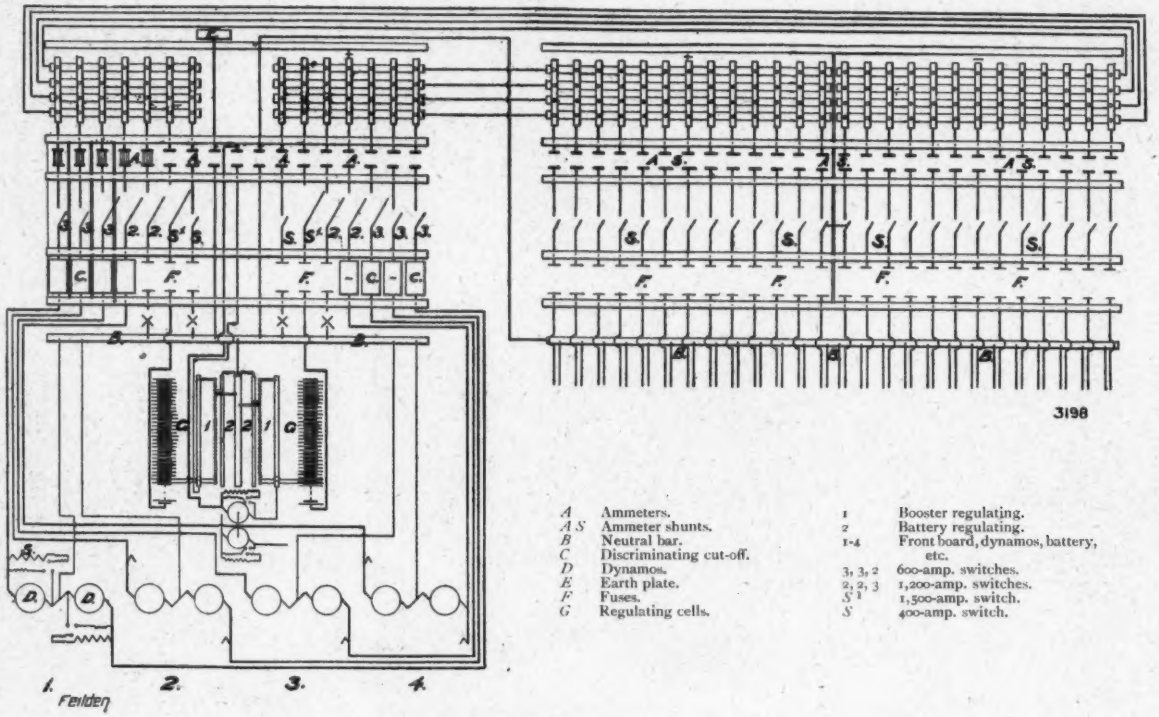
Fig. 13 is a diagram of a direct-current board for lighting only, and without any external balancers, two dynamos being driven by one engine or the same shaft. The cell principle of the gear is adhered to throughout in this case, though the arrangement differs somewhat from the foregoing.

The positive and negative cables from the two dynamos are brought to either side of the board, the currents from each passing through a discriminating cut-out switch and ammeter to an 8-hole plug fitting. At this latter the machine can be plugged up on any of the four bus-bars arranged at the rear of the fittings.

A shunt-regulating hand-wheel and field-breaking switch are fitted below the respective panels of each machine cable. The positive and negative boards are separated by the hand-wheels which operate the accumulator switches, these being fixed above the board in the battery-room. The earth neutral wire and booster ammeters are also mounted in this dividing panel. Referring to the general arrangement in Fig. 14, the positions of the various apparatus will be made clear. The positive and negative boards receive their cables from each side of the generators, current entering at the bottom of the particular panel for the machine.

Discriminating cut-outs for heavy currents occupy one cell of the dynamo panels, the other compartment containing the ammeter; while above this, at the top of the slate is the bus-bar fitting with holes for plugging through to the bar behind. On the panels supplying the motor for the booster and the accumulators, a quick-break switch is used in conjunction with a fusible cut-out, breaking the circuit in oil. A slate slab at the top of the gear acts as a rest for the machine voltmeters, as well as serving to support the upper portion of the bus-bar fitting, which is of unusual length in this case. The regulating table, with the field switch and rheostat hand-wheel is fixed below the machine panels, the particular handle occupying a position directly in line with the machine controlled, so that mistakes on the part of the switchman may be considerably lessened. A multiple-way voltmeter switch is also attached to the same slate frame below the accumulator switches, and the leads from these are connected by means of pilot wires with some distant point on the feeders.

The battery switches are operated by means of the handwheels, which are seen to occupy the centre of the gear between the positive and negative boards. The switches themselves are fixed in the accumulator room, and the handwheels at the board are connected to them by means of bevel gearing fixed in the mos



A	Ammeters.	1	Booster regulating.
AS	Ammeter shunts.	2	Battery regulating.
B	Neutral bar.	1-4	Front board, dynamos, battery, etc.
C	Discriminating cut-off.		
D	Dynamos.	3, 3, 2	600-amp. switches.
E	Earth plate.	2, 2, 3	1,200-amp. switches.
F	Fuses.	S^1	1,500-amp. switch.
G	Regulating cells.	*S*	400-amp. switch.

FIG. 13.—DIAGRAM OF CONNECTIONS: DIRECT-CURRENT BOARD FOR LIGHTING ONLY.

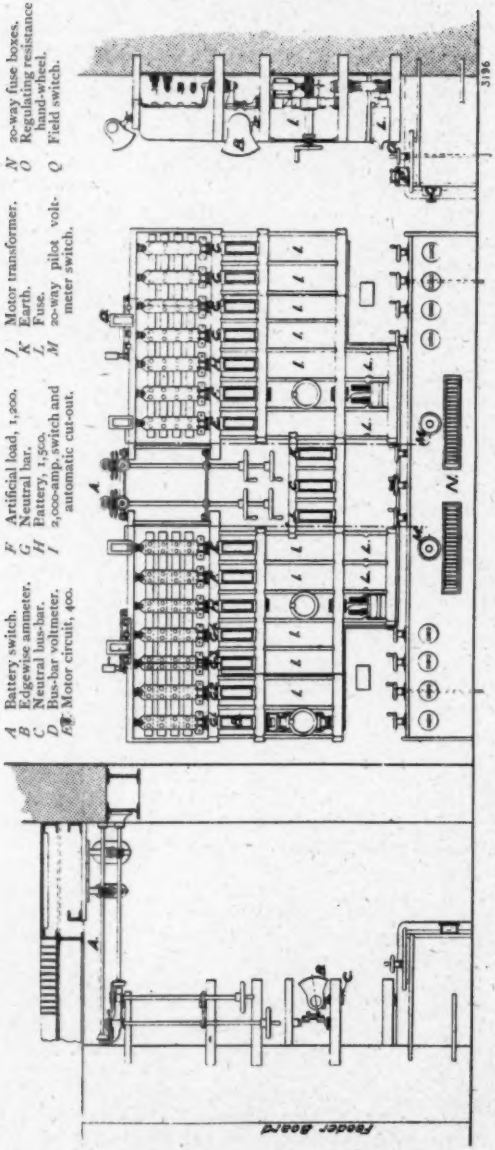


FIG. 14.—GENERAL ARRANGEMENT OF DIRECT-CURRENT BOARD FOR LIGHTING ONLY.

suitable position. An indicator running the whole length of the gear indicates to the attendant the number of cells cut in or out as the case may be. This arrangement of the battery regulating switches is probably as convenient as is possible to be, as the presence of the switches themselves in the cell room dispenses with the necessity of running a number of large cables to the switchgear, which must needs be some distance from the battery room. The cables in question not only present difficulties in running, but also in fixing neatly to the board itself.

The bus-bars at the top of the main slate frame are made up of bare copper strip carried on supports, well insulated from, but firmly fixed into the wall. Sockets are arranged along the bars to come in line with corresponding holes in the fittings which stand up in front of them. These latter, stout gun-metal castings, are firmly bolted at their lower ends to the main bus-bar fittings, the upper extremity of the casting being supported by a set screw, bolting into a small shank fixed to the topmost slate. Connection between the bus-bar and front fitting is made by inserting a special expanding plug. This consists of a copper tube having each end tapered inside and rendered flexible by means of saw cuts, down its length. A brass spindle with travelling and fixed cones attached is placed in the copper tube, and by rotating the spindle the cones are made to move towards one another, and by this means the ends of the copper tube become bulged out. The expansion, of

course, takes place in the holes of the fittings in which the plug is inserted and a good contact is thereby assured. A detachable handle is used for the withdrawal or insertion of the plugs, an operation which is performed from a ladder arranged to rest on the bus-bar main slate. A glance at the end view of the board will explain the arrangement of the bus-bars, as well as giving a good idea of the heavy-current switch or circuit-breaker. This is self-contained and is opened from the front

when a great similarity of design in the two is maintained. The feeder gear in question calls for no special remark save that the two poles of the system are separated as in the dynamo board, positive feeders with ammeter switch and fuse occupying one board and negative feeders with similar devices filling the other. Four bus-bars are provided, so that the feeders can be grouped or isolated as the circumstances of running may require.

Leaving gears of this class, which control heavy currents at low pressure, a glance

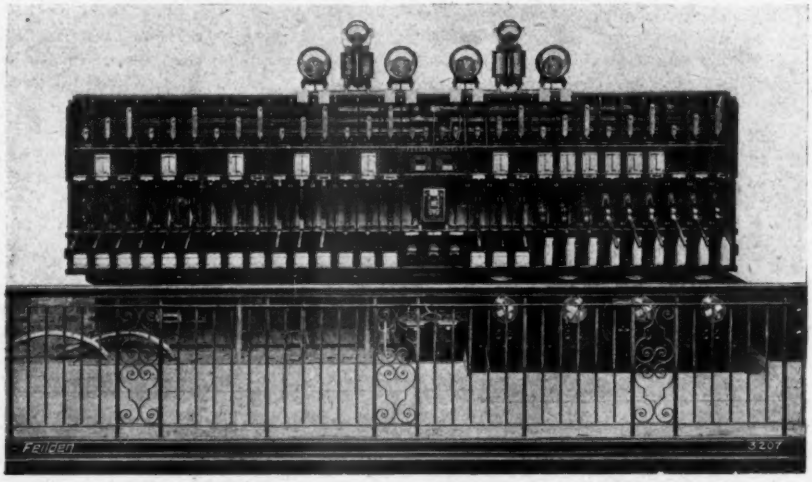


FIG. 15.—THREE-PHASE GENERATOR BOARD, CONTROLLING CURRENTS AT 5,000 VOLTS.

of the panel by means of an ambroin handwheel.

The feeder board is arranged to back on to the wall occupied by the dynamo gear, the one set of brickwork carrying the two slate frames. By this means the extension of either feeder or dynamo panels can be effected independently of one another though the proximity of the gears enables a certain symmetry of expansion to take place. Again, this separation of machines and feeders eliminates the possibility of mistakes, by a confusion of dynamo with feeder switches, especially

can be taken at those which are adopted for use on high-voltage circuits.

The conditions of design differ considerably from the foregoing in that additional precautions are needed, not only to assure good insulation from earth, but to guard against accidental contact on the part of the attendants. This latter is especially important, as, no matter what the care in design may be, occasions arise wherein the unforeseen will figure largely, though it must be said with the type of gear under consideration accidents are less liable to occur, even with gross care-

lessness. The general design of the gear binds itself to the protection of all parts carrying current, be these at high or low pressure, so that should one stumble against the board no harm would result; while it would be possible to fall amongst the high-tension bus-bars with similar effect. Everything is recessed in slate cells, and the outer edges of these provide ample space between the "live" metal and the operator; in fact, the entire board is designed so that nothing short of intentional injury can be sustained from it.

Fig. 15 illustrates a three-phase generator-board controlling currents at a pressure of 5,000 volts.

The slate frame is similar to that used for low-pressure gears, additional division plates being inserted between the high-tension bus-bars, as great differences in potential are maintained between them. Synchronisers and electrostatic voltmeters are mounted on the instrument slate at the top of the gear, where they can be more easily seen.

The dynamo panels with fuse, switch, and ammeter on each phase, occupy the right hand of the board. The three-phase bus-bars are fixed above the main slate frame, and connection is made between them and the panels below by means of a plug, which is inserted in a hole through a gun-metal fitting standing out from the bar. The phases A, B, and C can only be plugged to their respective bus-bars, as but one hole is made in the bus-bar fitting which is prolonged in the case of A phase to reach the topmost bar.

The regulating table below the machine panels accommodates regulating hand-wheel, ammeter and field-breaking switch, the rheostats being mounted directly below the table in a line with their respective hand-wheels.

The machine current passes along the bus-bars, down through a wattmeter and up again to the bars of the feeders, these latter being supplied through switching arrangements similar to the machines, with the exception that spring break switches are used in place of oil break. The potential transformers for the watt-meter are placed on the platform directly below the wattmeter panel, and the leads are taken to and from these converters through ebonite tubes; oil-break fuses for protecting the primaries being fitted in a recessed panel directly below the watt-meter. The arrangement of the dynamo and feeder frames on either side of a central wattmeter panel enables either section of the board to be extended without in any way interfering with the remainder of the gear. A board for controlling single-phase alternating currents at 2,000 volts is shown by Fig. 16, and the resemblance to the three-phase gear will be readily noticeable, the chief point of difference being in the bus-bars. Here one bar only is needed to carry high-voltage currents as the outer bus-bar, having the same potential as earth, is fixed below the bottom slate. The gear is equally divided between dynamo and feeder panels, the smaller machines are arranged in the centre of the gear, while the outside panels with switch handles connected, control currents from 1,500 kilo-watt alternators, so that two cells are arranged in parallel to carry the increased currents. The feeders are accordingly "sandwiched" between the dynamo-panels on either side and in the centre, each cell having its own link to connect it to the bus-bar. This latter is arranged in two halves, so that a set of dynamos can be run on a number of circuits on either side of the board during the time of heavy load, thus giving greater independence to the system. Synchronisers and volt-meters at the top of the gear enable any machine to be parallelled to either bar and both bars together. The terminals of the volt-meters and synchronisers are arranged in their respective supports, so that each instrument in standing on its own legs makes contact with the required terminals. When synchronising an alternator the machine switch is raised to "half cock," in which position it engages with a swinging contact coupled to the synchroniser and volt-meter. When the dynamo is in phase the switch is pushed a little further forward, when it is closed with the bus-bars and the running machines. When opening the switch again, the blades touch the synchronising

flapper but do not make connection with the instruments.

The foregoing examples are but a few of the forms in which this gear is manufactured, it being possible, with little modification of the frame, to meet almost any requirement. It will not be possible in the space of these few lines to describe these other examples; suffice it to say that the object of those illustrated is to give some idea of the advances made in switchgear design, and in conclusion the writer would draw special attention to the contrast between the classes of gear which form the subject of this article.

Competition in every industry leads to the final exclusion of the worst types, although the improvements in designs affected always meet with tremendous opposition until their merits are recognised. In many cases the evolution of an older class of manufacture will be brought about by slow degrees, as the progress made will be but a step beyond that already taken, a purchaser recognising that the article in question is an advance on older types. When, however, a competitor appears in the field against ancient methods, the difficulties to be overcome are more marked, in that the customer needs persuading that this change in principle embodied in the more recent articles is far away ahead of the most improved class of apparatus with which he is familiar. As long as the well-worn designs can be patched up and made to look effective they will form serious rival to the type which has to make a reputation for itself, in spite of its marked advantages over every other class of the same apparatus.

It is competition which keeps the older methods longer in our midst, as the prices

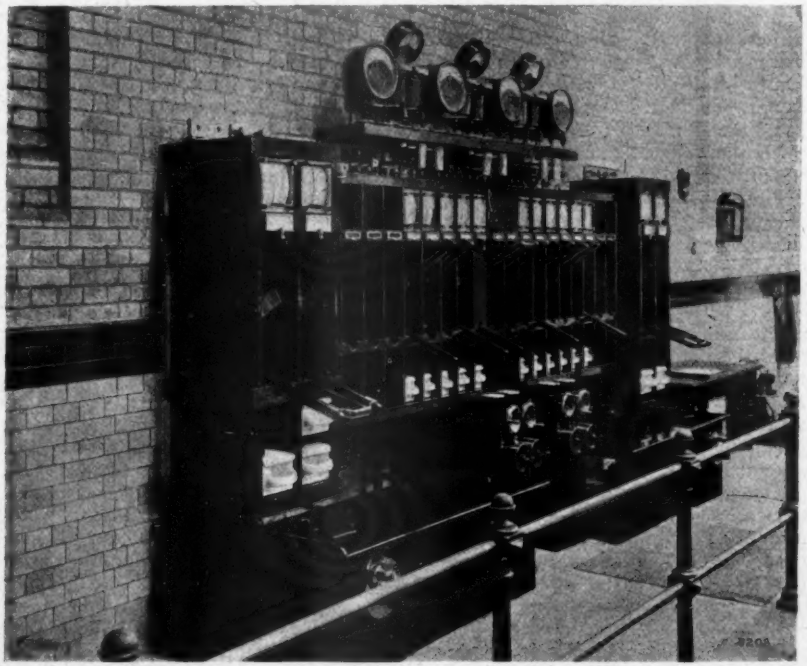


FIG. 16.—BOARD FOR CONTROLLING SINGLE-PHASE ALTERNATING CURRENTS AT 2,000 VOLTS.

can be made to compare very favourably with those demanded for new designs, and while the rivalry of manufacturers may be kept up as long as prices are kept down the harm done to the industry in question is being overlooked. This course of things will continue until the apparatus which has differed so much in principle from its competitors finally forces its way to the front.

The state of events outlined above represents what has occurred, and is occurring, in the electrical industry at the present time with regard to the switching apparatus needed for a generating station.

At first, engineers were blind to the value of a switchboard in the station, regarding it somewhat in the light of a necessary evil. Subsequent accidents due to faulty design aroused such interest in the subject that the controlling apparatus was regarded as *part and parcel of the station*, and the present stage of the matter can be regarded as a period in which the old and the new are pitted against one another for supremacy. Although there can be no doubt as to the issue of the contest, the majority of electrical engineers do not regard the switchboard in the manner in which they should. The lowest tender submitted will do, in spite of the design of the board, and when the work is completed the station is ofttimes marred by the introduction of a class of gear which may be not only dangerous, but out of date when compared to the rest of the plant. What can be more galling to an engineer than to find that his efficient generators are supplying current to a network through an old-fashioned and dangerous switchgear? Whatever efforts have been spent on the perfection of the generating plant, they are as nothing if the switching apparatus is not equally efficient.

The entire plant of the station must be efficient, and if this is not the case the particular system is not in a position to satisfy the demands of consumers, as there will be doubts as to the capabilities of the faulty item to do its work.

That most modern stations are fitted with inefficient switchgear goes almost without saying, and the object of these lines is to bring home to engineers generally this fact. No central station manager should have reason to be ashamed of any portion of his works, but how many would permit an inspection of their switchboards, where the connections to the various parts are made. Especially is this the case in some high-pressure stations. A visiting engineer may like to see the back of the switchboard, but such a request is vetoed at once as dangerous in the extreme. "We cannot permit you to inspect our cable connections" is the reply, and the engineer must depart unsatisfied. Now, this should not be. The connections of the switchgear should be of such a character that everyone may see them. There should be no poking away in corners of high-pressure cables and contacts, places where men are sent with their lives in their hands, to carry out some necessary work. It is more than ever essential that charged metal should be *well open to view* so that the liability to come into contact with it will be reduced by reason of its prominence. Not only this, but the engineer in charge of the station will be able to see all work which may be going on in connection with the board, and not have to despatch men behind a board knowing that they may not come out again alive.

If success is to crown the efforts of engineers in the direction of long-distance generation and transmission, far greater attention will have to be paid to the switching appliances. The American and Continental practice of erecting flimsy boards to control high-pressure currents cannot be followed with safety, as the elements of these gears are antagonistic to success. It is here more than anywhere that a great discrepancy is noticeable with the switchgear, some of the largest and best stations abroad having gears which are little better than crude attempts at the construction of such apparatus. These are hard things to have to say, but the future of electrical engineering depends more on the switchboard than it does on any other part of the plant. It does not follow that because Continental and American engineers can lay down large power schemes they can also erect efficient switchgear. Experience,

in fact, proves quite the opposite. Inspect any German high-pressure station and carefully examine the switchgear, and, if you are allowed to do so thoroughly, the defects in design would immediately become apparent. This statement is not meant to convey any stigma to the name of Continental electrical engineering, but is put forward to show that switchgear design has not received the attention which its importance claims, in spite of the erection of enormous power-stations equipped with first-class generating plant. This circumstance needs the careful attention of engineers now that many large schemes are being set on foot in this and other countries, and every occasion should be taken advantage of to introduce only reliable apparatus. That such can now be obtained a glance at the types of gear described above will show, and from them it may be said with truth that the future is with the board having no rear connections. Introduced at a time when switchboards were in their worst state, it has since been so steadily improved that it has taken the place of many boards formerly a mass of dangerous cable connections.

Its reputation has been obtained as a high-pressure gear, and as such its merits are becoming more widely known; but it is also manufactured for low-pressure currents, in which field it bids fair to make equally rapid strides. Its particular advantages over other boards cannot be fully entered into here; suffice it to say that the principle upon which it is constructed deserves its general adoption by the electrical industry as the standard apparatus.

The future of electrical engineering depends, probably, more on the switchboards in the large-power stations now in course of erection than on any other portion of the equipment. This section of the scheme must be as near perfection as brains and money can make it, and there is really no excuse for the introduction of gears of bad design now that such marked advances have been made.

The press of competition ofttimes forces obsolete and inefficient apparatus upon the notice of engineers, but such material is dear at any price. Its first low cost will probably be quite outbalanced by the failures of light and accidents upon it, due to bad designs. As long as engineers think that anything will do for a switchboard, so long will the old forms of gear be erected; but when it becomes fully realised that the controlling apparatus must be mechanically strong, readily accessible, with no hidden or rear parts, and practically immune from danger, as well as an article worth paying a good price for, then the appearance of our stations will be enhanced by apparatus which will not only compare well with the rest of the plant, but also do credit to the industry at large as a strong point in the whole scheme.

W. W. Warnlow

The illustrations and diagrams for the above have been kindly lent by The British Thomson-Houston Co., The British Westinghouse Co., and Ferranti Ltd., to all of whom the author herewith expresses his indebtedness.

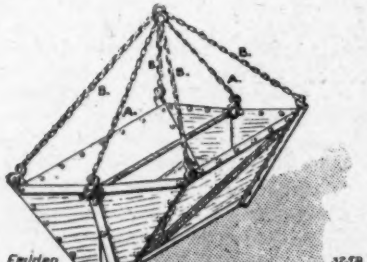
New Machinery, Appliances, Structures, & Processes

The Editor of FEILDEN'S MAGAZINE cordially invites his readers to send him early particulars of New Structures, Machinery, Improvements, etc., for inclusion under this section. FEILDEN'S MAGAZINE undertakes the whole of the cost of illustrations, merely stipulating that proper details, photos, blue prints or tracings are supplied. Where necessary, we will send our editorial representative to inspect and report on any special subject. The Editor, however, reserves to himself the right of accepting or rejecting any matter.

THE ROYAL ALEXANDRA (INTER-PROVINCIAL) BRIDGE AT OTTAWA, CAN.

(Continued from page 459.)

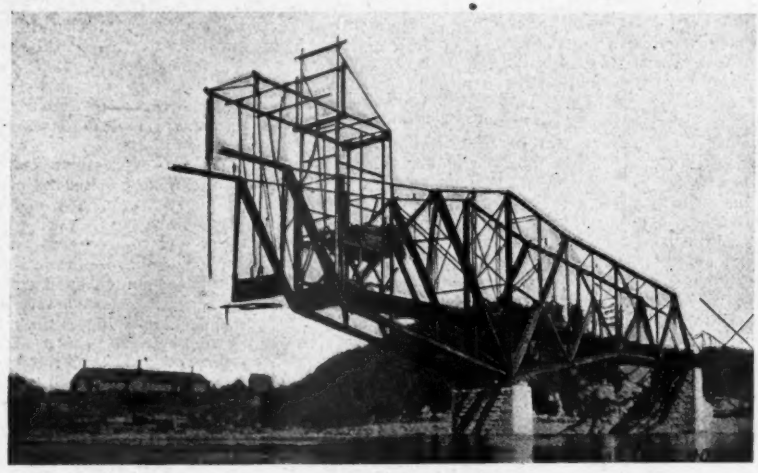
THE drill employed in the survey of 1894 was employed, but it was unfortunately found to be impossible to obtain satisfactory results on account of the great vibration. Government was then solicited for permission to deposit the remaining concrete to its calculated height, conditional on a satisfactory core from top to bottom being given. This was done, and once again the concrete was deposited, after a preliminary washing-off the top of the old deposit effected with a steam pump. The proportions of the concrete in the last deposit were increased to one of cement, one of sand, and as much stone as it would take, in consequence of the test which had to be made and the impossibility of obtaining any facts regarding any previous borings in concrete. Platforms were located on the Hull shore, the concrete being shovelled into the kibbles, drawn to the pier on sleighs. The sand and water were slightly warmed, a very small amount of salt being employed, the temperature of the concrete when placed in the kibbles averaging 55 to 58 degs. Fahr., which did not vary before being deposited under water. Whilst the concrete was being deposited in the lower part of the caisson a diver was told off to report as to whether it was levelling itself or not, it having been suggested that the concrete should be raked over or shoved with a hoe to the sides and into the nose at the bow, but the report showed that it was filling up to the sides of the caisson by itself most satisfactorily.



CONCRETE KIBBLE: CAPACITY 29 CUB. FT.
A Lifting chains *B* Tripping chains.

On the caisson being un-watered the best diamond drill procurable was started in the concrete, the first bit used giving a core of $2\frac{1}{8}$-in. diameter. The hole was made to 40 ft. when, the wall giving much trouble, it was decided to start a new boring. No difficulty was experienced in the accomplishment of this until nearly the bottom of the pier was reached, when the drill's vibration became so intense that collars had to be attached to the tubing, and when approaching the bottom, the bit was changed for a smaller one, giving a core of $7\frac{3}{8}$-in. diameter, this being employed until bed rock was touched, and a bit brought up: it was obtained in pieces from about 2 to 6 ins. long.

The concrete, in the case of all the piers, was deposited through the water until a point of about 3 ft. below the extreme low-water mark was reached, and after it had been sufficiently set, the water was pumped out and the concrete levelled up to within 2 ft. of low water, ready for the masonry. The kibble employed was very satisfactory, as, owing to its wedge shape, it made barely any disturbance in going through the water. Its capacity was 29 cub. ft., the doors opening from the bottom, and every precaution being adopted to prevent its being tripped before reaching bottom.



INTER-PROVINCIAL CANTILEVER BRIDGE: ERECTION OF CANTILEVER ON THE OTTAWA SIDE.

The canvas cover used was securely tied to each bucket before it was lowered.

Several tests *re* No. 2 pier were made when the first deposit of concrete was being laid. A kibble full was put down in the caisson at the usual speed to about 60 ft., and then raised slowly to the surface. In consequence of the flat surface of the cocnrete at the top of the bucket, the water offered a strong resistance to motion through it, giving a severe test for wash. On the bucket reaching the surface, very little wash was noticed, and two cement barrels were filled from the top and put under water to set. After two weeks a diamond drill was run through them in several places, giving good core. When the caisson was nearly completed, one more test for wash was made. A large wooden box (with a capacity of over two cubic yards) was made, and sunk on top of the concrete deposit in about 8 ft. of water. A kibble was then filled with concrete and let down through the ice into the stream outside the caisson, to a depth of over 50 ft. It was raised with the idea of lowering it into the box, but (owing to a miscalculation) the latter had been made too small, and it was necessary to trip it above the box, allowing the concrete to sift through 3 ft. of water. This was repeated with another bucketful, which filled the box.

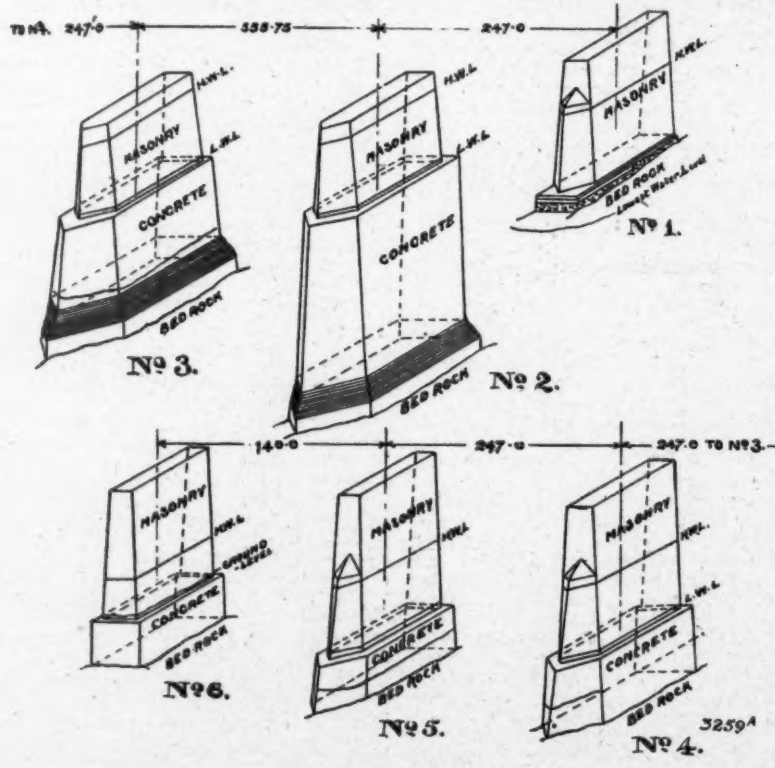
Solid masonry is employed for all the upper portions of the piers, no concrete backing being used, the ordinary specifications for first-class masonry being followed The bridge seats and copings are hammer dressed, and the remainder rock faced, concrete being employed for all the trestle pedestals and for the abutments of all spans over streets.

Three tracks of 75-lb. steel rails, with crushed stone ballast, have been laid from the south end of the bridge to Central Station, the two outside ones being now operated by an electric service from Ottawa to Aylmer across the bridge on the highway portion, the centre rail being used for the convenience of the trains of the Ottawa Northern and Western Railway, being also intended to carry the trains of the Pontiac Pacific Junction Railway. In order to make the connection with the Canada Atlantic railway tracks at Central Station, it was found necessary to cut out a portion of the abutments of the Sappers' Bridge (which is an historic stone arch which was built over the Rideau Canal in 1827). This abutment of a 24-ft. thickness had walls varying from two to four on the south side, the top being about 2 ft. thicker than the bottom. Despite the fact that the lime had deteriorated badly the masonry held together in astonishing fashion. Between the walls earth filling had been chiefly used. The subjoined summary of a few of the quantities will prove of interest:—

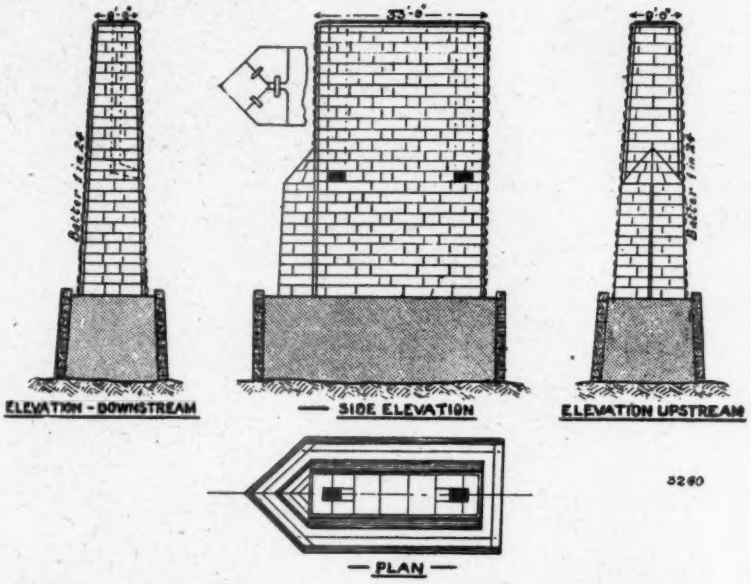
	Sawdust.	Concrete.
Pier No. 2.....	1,000 cub. yds.	2,579 cub. yds.
Pier No. 3.....	800 ,,	1,462 ,,
Pier No. 4.....	370 ,,	728 ,,
Pier No. 5.....	300 ,,	394 ,,

The following are the loads adopted by the Inter-provincial Bridge Company for the design of the superstructure subjected to the approval of the Dominion Government. The assumed railway load was of two consolidation locomotives, these bearing 17,000 lbs. on the front truck, with 36,000 lbs. on each driver axle and 22,000 lbs. on each tender axle, being followed by a train load of 3000 lbs. per lineal foot. Forty-seven feet was the total wheel-base of each locomotive, this including the tender, the truck of the second locomotive being eight feet behind the rear tender wheel of the leader. The electric railway load had an assumed weight of 30,000 lbs. on two axles placed 7 ft. apart, whilst the cars behind were separated by 30 ft. The roadway loading was approximated at 40 lbs. per square foot on two 8-ft. roadways, for stresses in the trusses, with a road roller on an 11·2 ft. wheel base weighing 26,000 lbs. for stresses in the floor system. For the foot walks the loading was assumed at 20 lbs. per square foot on two 5-ft. walks, for stresses in the stresses, and 70 lbs. per square foot for stresses in the floor system.

As the Government expressly stipulated that there should be a clear waterway above the high-water line of 45 ft., it being also the wish of the bridge company to keep the base of the rail as low as possible—to obviate grades in the approaches — the general arrangement of the suspended span trusses was in accordance with these views. For the greater economy of masonry in the main piers the shoes were located as near as was practicable to the river surface, the lower chords being inclined. In addition to effecting a reduction in the steel weight, this



NEW OTTAWA BRIDGE: DETAILS OF PIERS.



INTER-PROVINCIAL BRIDGE, OTTAWA: GENERAL DRAWINGS OF PIER NO. 4.

plan had the further advantage of lowering the total height of the main towers. Wind pressure was specified at 30 lbs., the surface affected being represented in the ordinary method, as twice the truss area and once the floor system. In order to give the maximum stresses in any member a moving train of a 10-ft. height was also taken into consideration. For the purpose of distributing the wind stresses more evenly between the upper and lower chords, and to remove the difficulty of providing an efficient shear joint for a large stress at one point, the stresses in the top laterals from the suspended span were transferred to the top lateral trusses of the cantilever instead of being conveyed in the usual way, namely, by the end post bracing of the suspended span to the bottom lateral system. The upper laterals were designed to resist tension only, but for the sake of effect were latticed vertically, the lower laterals being intended to act both in tension and compression, this plan being found to be more economical. besides simplifying the difficulty of providing for secondary stresses induced at the pin joints. Wherever feasible, sway bracing has been used between all compression members, the wind pressure from the floor and train being transferred by knee braces connecting the floor beams and lower chords.

Whilst the cambering of the suspended span was made as ordinarily, by lengthening the upper chords, each member in the anchor and cantilever was corrected for its own alteration of length, due to the dead load stresses and pin play, all deflection due to live load at the cantilevers' ends being compensated for by shortening some of the upper chords. The finished bridge shows a slight rise in the floor on a sufficiently regular curve, the anchor arms also having a slightly observable camber. These were so made as to be self-supporting before the erection of any of the cantilever arms was made, as it was thought that the scows used for the support of the falsework might probably be withdrawn before the erection of the cantilevers. This necessitated a temporary strut and also the provision of tension at the lower chord splices. During the process of erection the bottom connection of the suspended posts was reinforced for the support of the traveller, whilst, with the intention of reducing the thickness of the material, and the consequent long rivets, the lower chords of the anchor and cantilever

arms were made with three ribs. For the purposes of calculation the pin stresses were considered as continuous girders, having the rest of three rigid supports formed by the three ribs just mentioned.

The anchorage scheme is a steel grillage located 33 ft. below the surface of the masonry forming the counter weight and being composed of two plate girders running across the pier. Above this several 15-in. I-beams, built in the masonry, are supported, the main girders being supported by groups of such beams bearing on cast bolsters through which pass the adjustable hangers. To enable a workman to reach the entire length of the bars, ladder rungs were placed in the masonry. Opened to the public on March 5th of last year, the first passenger train crossed the bridge on the 22nd of the ensuing month.

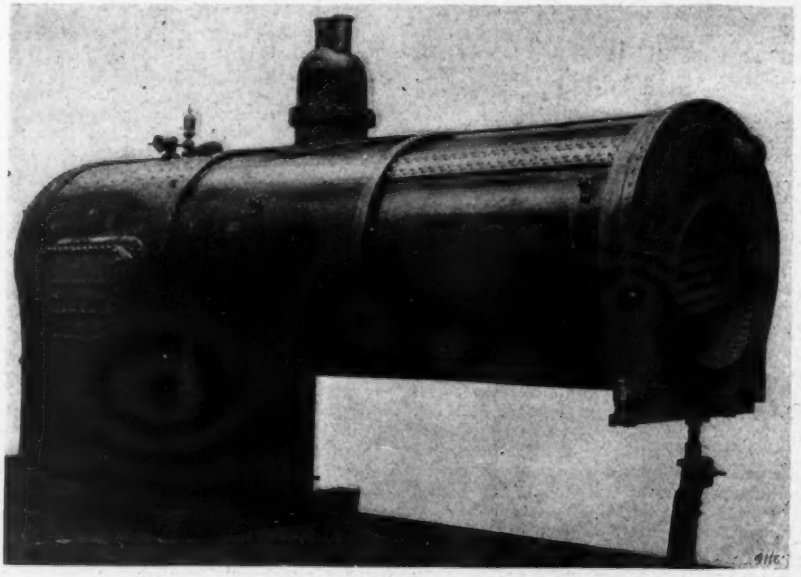
THE WATER-TUBE LOCOMOTIVE BOILER ON THE L. & S. W. RAILWAY.

IN spite of the extensive adoption, within recent years, of the water-tube type of boiler for both land and marine service, but little has been heard of the possibilities of this type of steam generator in connection with the railway locomotive. This is more particularly striking in view of the quick steaming requirements of the modern locomotive and the peculiar qualities which appear to be invested in the water-tube boiler for meeting them.

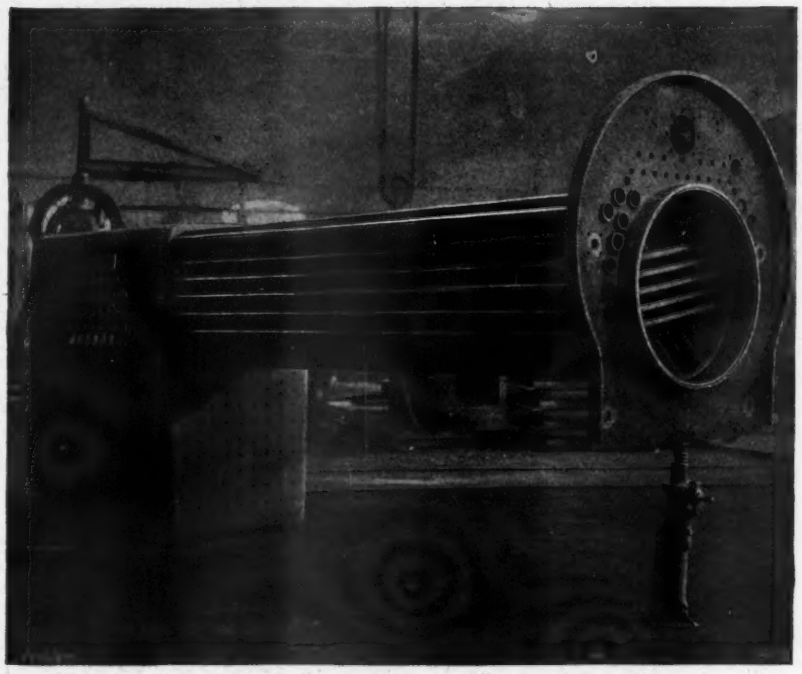
The apparent diffidence with which the water-tube boiler problem has been treated by both locomotive builders and superintendents has met with one notable exception in the case of Mr. D. Drummond, the Locomotive Superintendent of the London and South-Western Railway, who for some years past has been carrying on experiments in the use of water-tubes with a great amount of success.

Visitors to the Glasgow Exhibition will remember that the exhibit of Messrs. Dubs & Co. consisted of one of Mr. Drummond's engines, fitted with cross water-tube boilers at the top of the fire-box, a description and photograph of which appeared on pages 58 and 59, Vol. 5, of this magazine.

Altogether over one hundred engines on the London and South-Western Railway have been fitted with cross water-tube boilers in this manner, and up to the present time without any complaint being received from those responsible for the running of the



COMPLETE BOILER, SHOWING SIDE DOOR TO FIRE-BOX AND FRONT END OF FLUE WITH CROSS WATER-TUBES.



VIEW SHOWING AUXILIARY FIRE TUBES FOR STIFFENING FRONT OF FIRE-BOX

engines, nor have any repairs been necessitated during the last two years.

Engines so fitted have proved themselves to be more economical in coal consumption than those fitted solely with flue tubes. The success of this well-tested arrangement has determined the company to fit the whole of their locomotives in this manner, and furthermore led Mr. Drummond to pursue his investigations further, for which purpose he has recently built a locomotive entirely on the water-tube principle.

Here the fire-box is fitted with forty transverse horizontal tubes, while a single cylindrical flue of large diameter, traversed by 215 cross water-tubes arranged diagonally, replaces the usual horizontal flue tubes.

To assist in staying the upper portion of the front end of the fire-box, nine flue tubes of the ordinary type have been fitted, running from the fire-box to the front tube plate.

The total heating surface is only 736 sq. ft.

From tests extending over the four months that this engine has been in existence, the results show that the coal consumption averages 1 lb. of coal per mile less than that of flue-tube engines, having a heating surface of 1,291 sq. ft., and doing the same class of work.

This saving in coal is undoubtedly due to the more vigorous circulation of the water and the retardation of the hot gases by the transverse tubes in the main flue causing them to part with more of their heat.

This remarkable result should be eminently gratifying to the designer, and will lead him perhaps to construct a boiler of similar design to larger dimensions, where the economical results would show themselves still further, when compared with those obtained from flue-tube locomotives.

ELECTRIC PUMPING PLANT AT ELDON COLLIERY.

MESSRS. ERNEST SCOTT & MOUNTAIN, Limited, Electric-Light and Power Engineers, Newcastle-on-Tyne, who make a speciality of mining machinery, *i.e.*

electric pumping, hauling, coal-cutting machinery, etc., have recently completed an electric pumping plant for the South Durham Coal Company for their Eldon Colliery, this plant being one of the largest of its type in the Kingdom.

The plant consists of a compound coupled horizontal engine with

High-pressure cylinder			18 ins.
Low	„	„	30 ins.
Stroke	...	...	40 ins.

running at 80 revs. per minute, and capable of giving 440 i.h.p., with a steam pressure of 100 lbs. per square inch. This engine is used for driving the pumps at present installed, and has sufficient capacity for driving a third set of pumps, which it is proposed to place at the 600-ft. level, and also the dynamos for working the coal-cutting machines.

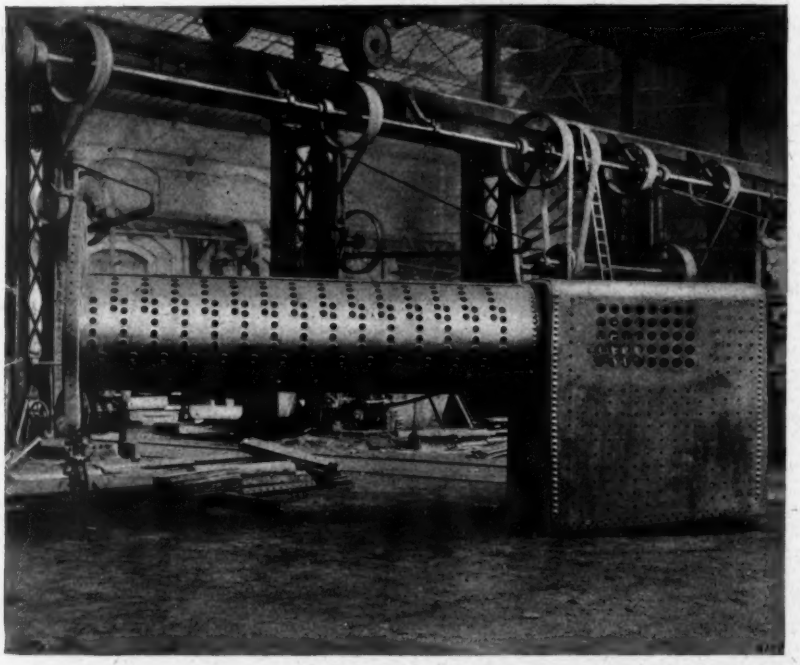
The engine drives by cotton ropes on to a "Scott and Mountain" over-compounded multipolar generator of their latest type, the machine being constructed to give an output of 220 kilowatts at an e.m.f. of 500 volts on open circuit or 550 volts at full load, when running at a speed of 400 revs. per minute.

The dynamo is fitted with extended bed-plate with outer bearing, the pulley-shaft being independent from the armature-shaft and coupled by turned steel bolts.

The current from the dynamo is taken to a main-switchboard on which the usual instruments are fitted, *i.e.* ampèremeter and voltmeter, also an overload circuit-breaker and shunt-regulator.

The generating machinery is placed at the Harry pit, the current being taken to the John Henry pit, a distance of half a mile, by overhead conductors, consisting of four cables, each composed of nineteen wires, No. 11 s.w.g., run on poles with insulators. At this point it is taken down the shaft through heavily insulated and armoured cables to the pump-room, the length of the shaft-cables being 150 yds. each.

In the pump-room there are two sets of three-throw ram-pumps of 500 galls. per minute capacity or, collectively, 1,000 galls.



MR. DRUMMOND'S WATER-TUBE BOILER: THE FIRE-BOX AND WATER-TUBE FLUE.

against a 400-ft. head. The pumps are of the latest design with gun-metal rams, independent pump-barrels, valve-boxes and connecting-pipes, and are driven by motors, capable of developing 120 effective h.p. each, at a speed of about 450 revs. per min. These motors drive by cotton ropes on to the pumps, which system of driving takes all jar off the motor armature. The plant has now been constantly at work for over two months.

In order to prove the efficiency an exhaustive set of tests have been made with the following satisfactory results. One boiler, 30 ft. long by 7 ft. diameter, of the Lancashire type, was easily capable of supplying steam to the engines, when driving the two sets of pumps to their full capacity, and the consumption was 906 lbs. of coal per hour, the coal being of ordinary quality.

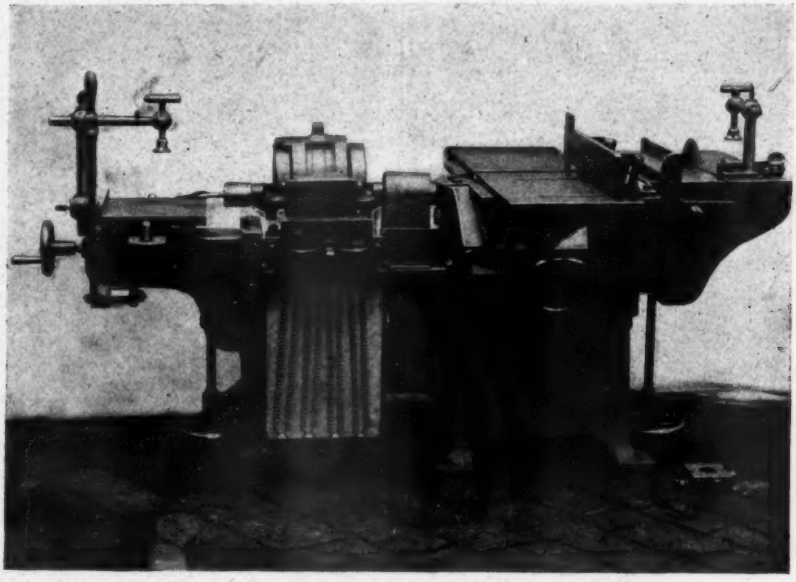
The pumps, working against a head of about 400 ft., delivered 64·8 galls. of water per lb. of coal used in the boilers.

The efficiency, taking the actual electrical output at the dynamo terminals and the horse-power in the water pumped, the pumps being a distance of 1,000 yds. from the generator, was 72·7 per cent.

The efficiency, taking the electrical horse-power at motor terminals and the actual horse-power in the water pumped, was 77·4 per cent. The efficiency of the motors was 91 per cent.

The efficiency of the pumps, *i.e.* the difference between the actual horse-power applied at the motor shaft and the horse-power in the water delivered, was 85 per cent.

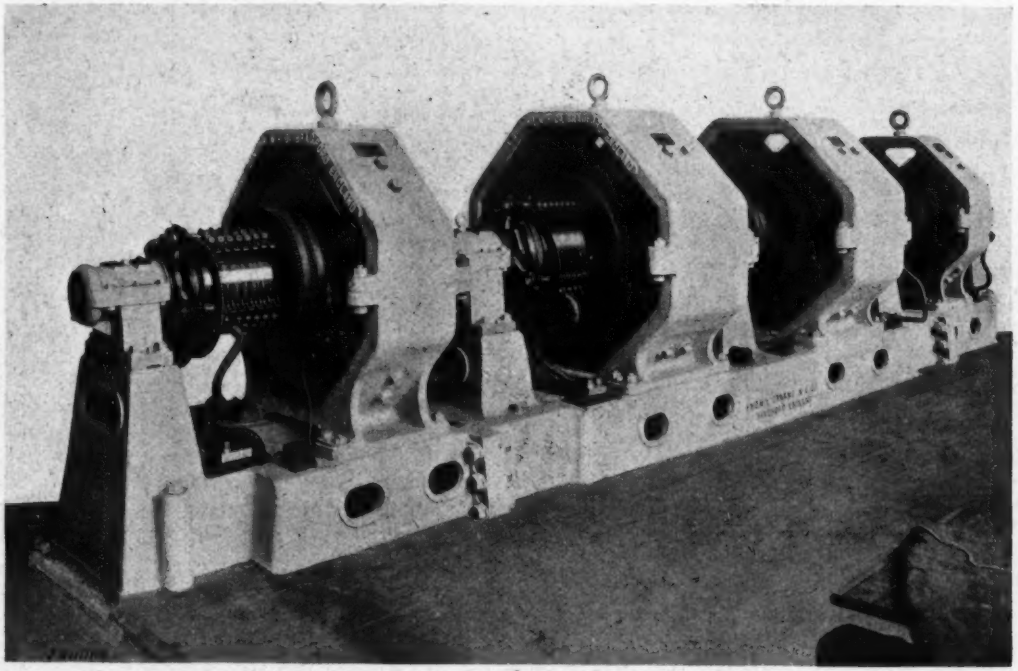
The high efficiency of the pumps is due, no doubt, to their slow speed, and also to the use of machine-cut gearing throughout and the very large valves used, but although this efficiency is high there is no doubt a still higher efficiency would be obtained against greater heads.



ELECTRICALLY DRIVEN WOOD-WORKING MACHINE FOR TRAMCAR WORK.

ELECTRICALLY DRIVEN WOOD-WORKING MACHINE FOR TRAMCAR MAKING AND REPAIRS.

THIS machine, which is illustrated above, has been recently constructed by Messrs. John Pickles & Son, Hebden



THE LARGEST BALANCER BOOSTER SET.

CONSTRUCTED FOR THE BRADFORD CORPORATION BY THE PHŒNIX DYNAMO MANUFACTURING CO., BRADFORD.

Bridge, Manchester, for the Wallasey Urban District Council, Birkenhead.

It is a handy and useful machine, capable of performing a variety of operations, such as planing, jointing, trying-up short lengths, chamfering, moulding, sawing, tonguing, tenoning, boring, etc.

The central portion of the machine is adapted for planing timber up to 12 ins. wide, the timber being passed over the cutter by hand, and planed perfectly out of twist. The tables are adjustable on both sides of the cutter, and can be opened or closed, as may be required. On the right hand of the machine is the sawing, etc., apparatus, consisting of a rising and falling table. The spindle end is adapted for carrying a circular saw, square block for tonguing and grooving, or a tenon cutter head.

The boring and slot mortising apparatus is fitted on the left-hand side of the machine.

The machine is driven by a 4-b.h.p. alternating-current motor, with a special coupling attaching directly to the spindle, as shown.

THE LARGEST BALANCER BOOSTER SET.

We illustrate on page 552 a large balancer Booster set recently made by the Phœnix Dynamo Manufacturing Co., of Bradford, to the order of the Bradford Corporation, and installed in the latter's Bolton Road Electricity Works.

This set, which is the largest Balancer Booster set in use, is comprised of two centre balancing machines, each of 100-kilo-watt capacity, having coupled at each end a 30-kilo-watt Booster.

The specified outputs of each of the centre machines are 300 amps. at 230 volts, and of the Boosters 300 amps. at any e.m.f. from 5 to 100 volts; the speed of the combination being 500 revolutions per minute. All of the machines have the usual former slot winding, and the armatures are well ventilated. Carbon brushes are used, and the current density in these is kept under 30 amps. per sq. in.

Five bearings are fitted and couplings between each of the armatures, so that it is possible to effect various combinations in running in the event of any armature breaking down. The bearings are of the spherical-seated, self-aligning type, each fitted with two self-oiling rings.

The over-all length of the set is 21 ft., and the total weight is approximately 12 tons.

A complete switchboard was also supplied with the balancers, and the plant has now been running continuously for the past six months, giving the greatest satisfaction.

A NEW DEPARTURE IN ARC LAMPS.

The struggle between the various forms of artificial light still goes merrily on. Gas is improving its methods under the stress of competition, the voltage at which electric incandescent lamps can be worked is increasing, and the cost of current as generated by supply stations is steadily going down. The arc lamp is an old servant of the public, and it might have been thought that, with the exception of improvements in matters of detail, nothing remained to be done in that field. Yet it will be apparent, after a description of the latest form of arc has been given, that a completely new departure has been made, which may have far-reaching results. The practice has been, with open arcs, to run with an arc of only a

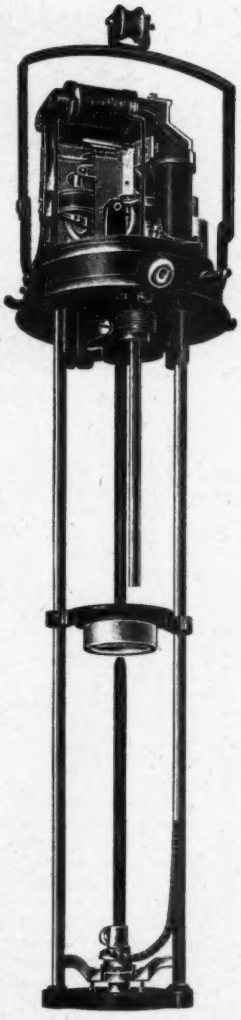


FIG. 1.—SHOWING THE "FLAME ARC LAMP" WITH GLOBE AND CABLE REMOVED. THE INVERTED FIRE-CLAY BASIN, WITHIN WHICH THE ARC IS FORMED AND ROUND WHICH IT PLAYS, WILL BE NOTICED. THE FEEDING MECHANISM IS SHOWN ABOVE.

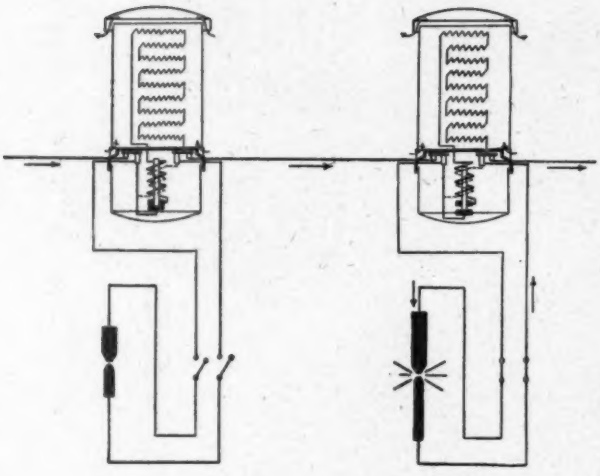


FIG. 2.—DIAGRAM SHOWING THE UNION ELECTRIC CO.'S METHOD OF USING A COMPENSATING RESISTANCE WITH ARC LAMPS IN STREET-LIGHTING WORK. IN THE DIAGRAM THE LAMP ON THE RIGHT IS BURNING, THAT ON THE LEFT IS EXTINGUISHED, THE COMPENSATING RESISTANCE TAKING ITS PLACE, AND, IT IS CLAIMED, THE CIRCUIT REMAINING PRACTICALLY UNCHANGED.

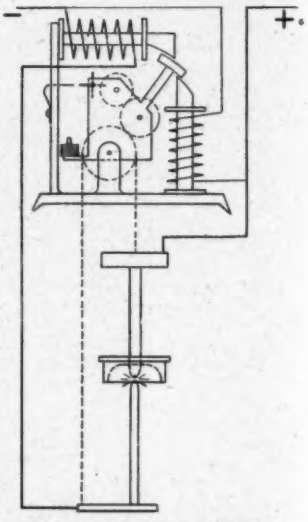


FIG. 3.—A DIAGRAMMATIC SKETCH SHOWING THE ARC WITHIN ITS FIRE-CLAY BASIN, REFLECTOR, AND THE FEEDING MECHANISM. THE ARMATURE WILL BE NOTICED MOVING IN ITS CURVED PATH BETWEEN THE MAIN AND SHUNT MAGNETS, AND EITHER ARRESTING OR RELEASING THE DETENT.

very short length, just sufficient to prevent the formation of the mushroom growths which were so troublesome in the early days of electric lighting. A long arc, with the usual type of open lamp, is a flaming arc, and a flaming arc gives trouble. It burns its carbons away much more quickly than the non-flamer, it burns them in a very uncertain form, and it causes the feeding mechanism to frequently fail in its office. Further, the long arc has a violet look about it which is somewhat ghastly to the observer, and it is stated that ladies' complexions in a ball-room suffer somewhat in appearance from this. The enclosed arc is a long arc, and it has some of the objectionable features of the open arc when burning long; but much is forgiven to the lamp which can be run off any 100- or 110-volt circuit, without special arrangements, and which does not require trimming for weeks together.

In the new form of arc lamp, however, the arc is long, it burns in the open, unenclosed, and yet it is not ghastly, and is stated to furnish more light for a given expenditure of energy than any of its rivals. The "Flame Arc Lamp," as it has been called by its inventors, which is being placed on the market by the Union Electric Co., of 151, Queen Victoria Street, is similar in outward appearance to other arc lamps, but when burning the rays of light emitted are yellow or golden instead of violet or white, as in the ordinary arc. When examined, it is found that the arc is from $\frac{1}{2}$ in. to $\frac{5}{8}$ in. long, instead of the $\frac{3}{32}$ in. common to the open arc. Further, it is noticed that the arc—which is flaming, as all long arcs are—burns immediately under an inverted basin made of fire-clay, as shown in the drawing, the surface of the basin being covered by a fine white powder, deposited by the arc itself, as soon as it has been burning for a short time. The combination of the long arc with its flame, and the white-coated basin, which acts as a very good reflector, produces, the makers claim, a much stronger light for a given consumption of energy than is possible with the ordinary arc, either open or enclosed.

The lamp burns with a pressure of 43 volts. between terminals, and with a current of 9 amps. furnishes a light of 1,700 candles,

as against 895 candles given by a 9-amp. open arc, and 360 candles with the enclosed arc, the figures in each case being mean hemispherical intensity, and obtained by the makers of the lamp by very careful tests. The figures claimed for the alternate-current arc are even more striking. A "Flame Arc Lamp," working with alternate currents, taking 34 volts and 12 amps., is stated to give a light of 1,064 candles, mean hemispherical intensity, as against 410 candles with the ordinary open arc. Put in another form, a consumer can run a "Flame Arc Lamp" with 7 amps. in place of 10 amps., the usual current for lamps of this size, saving 30 per cent. in his bill for energy, and still have a 30 per cent. better light than with the ordinary arc lamp. Against this the carbons cost rather more than with the ordinary lamp, and they do not last so long as the latest forms of open arc; but the increased cost on these two items does not equal the saving in cost of current. The lamp is of the differential type, the mechanism, which is shown in the drawing, being a very pretty modification of that used in all Messrs. Korting & Mathiessen's arc lamps. It uses only very small carbons, and there is a crater in each, with all forms of current. The main magnet, fed with the same current which supplies the arc, separates the carbons, raising the upper carbon and drawing down the lower one, in the now usual manner. The feeding mechanism consists of a train of wheels whose motion is arrested, so long as the arc is burning normally, by a detent. As the arc increases, the armature is pulled along a curved path provided for it on the poles of the shunt-magnet, and at a certain

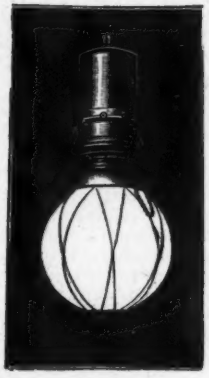


FIG. 4.—THE "FLAME ARC LAMP," WITH CASE AND GLOBE COMPLETE.

point releases the detent, a small but definite feed following, and the train of wheels again arrested, as when the arc is first formed.

One very important point remains to be mentioned in reference to the "Flame Arc Lamp." As mentioned above, it emits yellow rays, not violet, as in the ordinary arc. The colour of the rays are due to the carbons which are burnt in the lamp having been formed out of a mixture of charcoal and a salt of sodium, and they have the important property that if the sodium is present in sufficient quantity, as can easily be arranged, the light given is, for matching colours, the same as that given by the sun at noon.

The Wolverhampton Exhibition.

THIS exhibition, which was opened on May 1st by the Duke of Connaught, is the fourth, and certainly the most important of such enterprises yet attempted in Wolverhampton. Although the scheme is of an international character and wholly cosmopolitan in aim, it is nevertheless the Midland industries which are chiefly reflected therein.

In the preliminary article on pages 254-5 of this volume the various buildings were described, and to that article readers are referred for details of these very handsome structures. Coming more particularly to that portion of the exhibition which is our chief concern, we remark that the loan plant put down for generating the motive power required for driving and lighting exhibitors' machinery supplies some points of interest, particularly in the boiler section, where Messrs. John Thompson, Ettingshall Boiler Works, Wolverhampton, have two water-tube boilers on the Dürr system; and Messrs. Edwin Danks & Co., Ltd., Oldbury Boiler Works, Birmingham, have two others on the Cahall system, both of which types are unusual for this class of work. With the Babcock & Wilcox boiler the whole battery is capable of generating a total of 3,000 i.h.p. at a pressure of 180 lbs. per square inch.

The whole of the steam-pipe system connecting the boilers with the various engines, was constructed by Messrs. Lloyd & Lloyd; the feed heaters by Messrs. Joseph Wright & Co., Tipton; feed-pumps by Messrs. Joseph Evans & Co., Wolverhampton; valves and expansion joints by Messrs. Glenfield & Kennedy, Ltd., of Kilmarnock.

Coming to the electrical equipment, the generating station, which covers an area of 4,970 sq. ft., occupies a central position in the west half of the machinery hall, and contains the following sets:—

DETAILS OF ELECTRIC GENERATORS.

Engine Builders.	Dynamo Builders.	Volts at Terminals.	Total Ampères.	E.H.P. at Terminals.
Belliss & Morcom, Ltd.	Electric Construction Co.	500	800	536
,, ,, ...	,, ,, ,, ...	500	500	335
Robey & Co., Ltd....	Mavor & Coulson, Ltd.	500	800	536
,, ,, ...	Ernest Scott & Mountain	250	300	100
,, ,, ...	,, ,, ...	250	260	87
Wm. Sisson & Co.	Lancashire Dynamo Co.	250	400	134
Willans & Robinson, Ltd.	D. Bruce Peebles & Co.	500	1,000	670
Browett Lindley & Co.	Dick, Kerr & Co., Ltd.	500	800	536
	Total E.H.P. ...	...	...	2,934

In addition to the above, the Electrical Construction Co. have supplied a balancer capable of dealing with 200 amps. out-of-balance load.

The station switchboard is supplied by Messrs. Ferranti, Ltd., Hollinwood, Manchester, and is of their low-tension three-bar type, consisting of eight dynamo-panels and nine feeder-panels. Each dynamo and feeder panel is fully fitted out with all the necessary controlling and recording equipment; all the electrical connections and conducting parts of which are in front of the board (and not behind as is the more

prevalent custom), thereby bringing all conducting parts direct under the observation of the board attendant, and offering every facility for direct connection or disconnection being made.

The whole arrangement has been carried out upon a basis to give every satisfaction in manipulation, and to maintain high insulation resistance.

The board measures 23 ft. 8 ins. in length, 13 ft. in height, and is fitted with a platform raised 4 ft. above the floor level.

The three-wire system of distribution is applied as far as the feeder cables are concerned. These cables are supplied and laid by the British Insulated Wire Company, Ltd., Prescot, and are low-tension triple-concentric Class "A," insulated with impregnated paper, lead covered, and are laid in wood conduits, connecting the generating station and the various sub-stations or feeding points throughout the buildings and grounds. Each feeder is capable of carrying 250 amps. at 500 volts across the two outers, and 250 volts across the inner and each outer conductor.

Every arrangement has been made to facilitate the application of the electric motor for driving in connection with working exhibits, and a fairly uniform day-load is expected to be maintained at the generating station. All motors under 5 h.p. are connected to the 250-volt system, and all motors over 5 h.p. are connected to the 500-volt system, so as to minimise the out-of-balance load.

The machinery hall, industrial hall, and large section of the grounds are lighted by means of 10-amp. arc lamps and incandescent electric lamps of various types and candle powers. The arc lamps and resistances are supplied by the Brockiepell Arc Lamps Company, Ltd., London, the incandescent lamps by the Edison & Swan Company, Ltd., and the Hiram Maxim Lamp Company, Ltd.

The arc circuit-cables are supplied by Isidore Frankenburg, Greengate, Manchester.

The overhead wires for all outside arc lighting are supplied by the British Aluminium Wire Company, Ltd., London.

The grounds outside the park proper and surrounding the machinery hall, industrial hall, Canadian pavilion and adjacent buildings are lighted by gas drawn from the Wolverhampton Gas Company's service, and contract has been made with the Welsbach Gas Lighting Company, London, for the supply and erection of lanterns, mantles, and self intensifiers.

As to the machinery exhibits themselves, with one or two exceptions, arrangements were not sufficiently far advanced on the occasion of our visit to enable much to be said about them.

The Dominion of Canada is, as in other recent exhibitions, well to the fore, the Government having erected a pavilion covering an area of over 8,000 sq. ft., in which are a series of exhibits selected to show the natural resources of the country. Thus we find numerous agricultural products, fruit products, minerals, meats, and canned goods—for which Canada is famous—of every description. A casual glance alone suffices to impress one with the surpassing richness of this great Colony, and a closer inspection deepens the feeling of admiration we already have of the pushfulness and the innate genius of the Canadians. Canada is, indeed, the land blessed with "milk and honey,"—the land for emigrants.

Visitors on pleasure bent will find that they have been amply provided for, especially by the spiral toboggan, the Canadian water-chute, and the hall of laughter, etc. The art collection, which is one of exceptional interest, has been located in the Art Gallery.

EXHIBITS.

Edwin Danks & Co., Ltd., Oldbury.

This firm, as before mentioned, have installed two vertical water-tube boilers of the "Cahall" type, which are engaged in supplying steam for the exhibition central station.

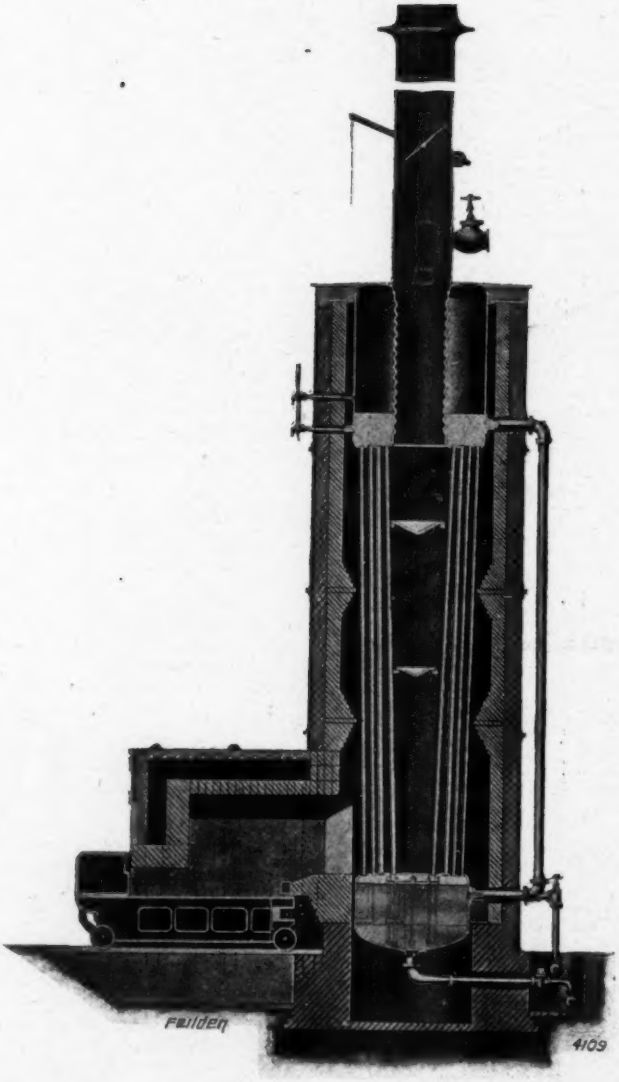
Each boiler contains 108 tubes, 22 ft. in length and 4 ins. in diameter, giving a heating surface of 2,500 sq. ft., which, added to the grate area of 50 sq. ft., gives a total of 2,550 sq. ft. The dimensions of the drums are as follows: top drum, 6 ft. 9 ins. diameter, 8 ft. 6 ins. height; bottom drum, 5 ft. 9 ins. diameter, 4 ft. length.

An idea of the general arrangement of the boiler will be gathered from the accompanying figure.

The boiler is capable of evaporating 10,000 to 12,000 lbs. of water per hour, and is arranged for superheating, although if any high degree superheat is required, an independent apparatus is added.

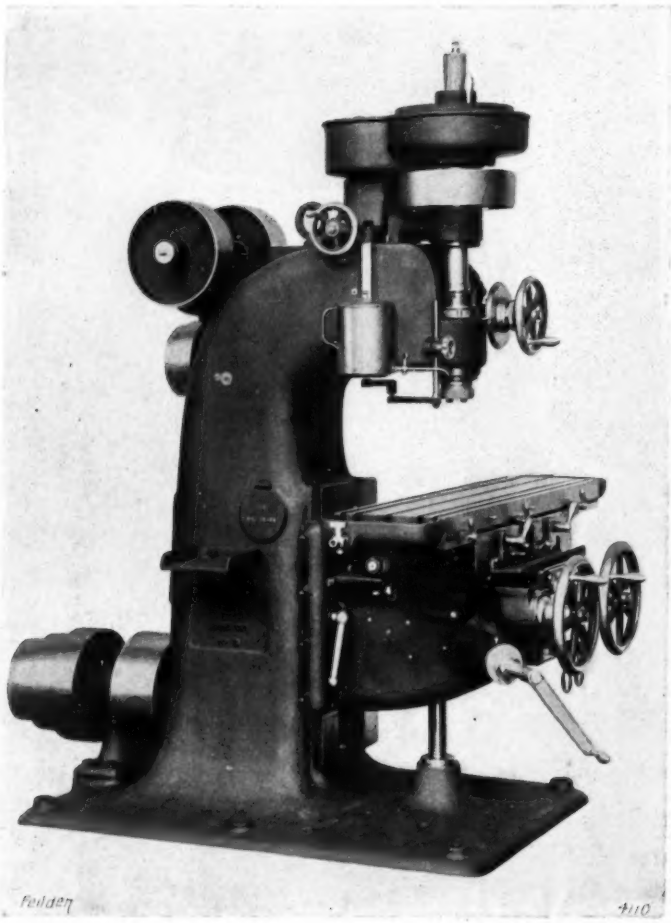
The special arrangement of the seating is an important feature of this boiler, as is that of the heating surface, which is fixed at nearly right angles to the normal path of the currents of heated gases, thus retarding their flow and absorbing a high degree of heat therefrom.

From its form of construction, it is freed from the trouble of scaling up, as the surfaces, being practically vertical, there is no chance for the accumulation of dirt, etc., on the heating surface: it all falls to the bottom of the boiler, where ample provision is made



THE WOLVERHAMPTON EXHIBITION: VERTICAL SECTION OF THE "CAHALL" BOILER BY MESSRS EDWIN DANKS AND CO., LTD., OLDBURY.

SUP



NEW VERTICAL MILLING MACHINE.

Shown at the Wolverhampton Exhibition, by Messrs. ALFRED HERBERT & CO., LTD., Coventry.

for readily and easily removing it whenever occasion requires.

The makers state that tests made with this boiler show that 85 per cent. of the theoretical analysed value of the fuel burned has been obtained in dry steam.

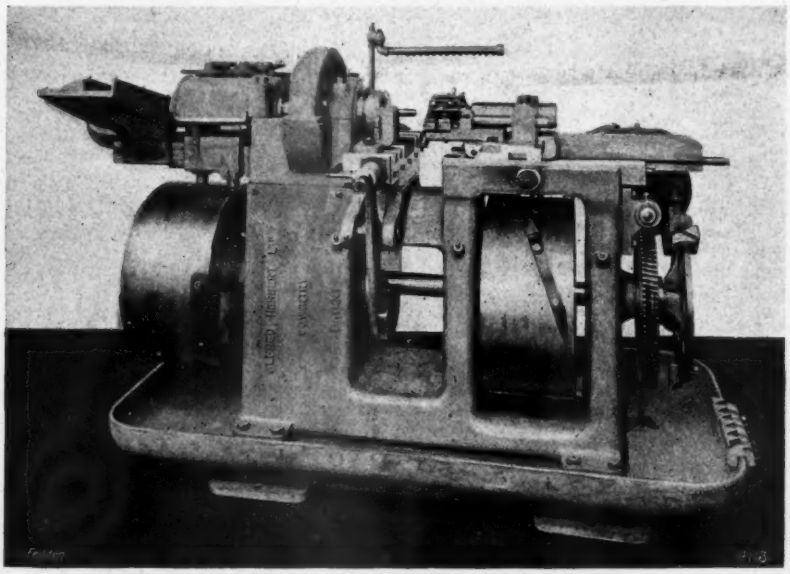
Messrs. Danks are also exhibiting in the grounds one of these "Cahall" vertical boilers without its casing, simply showing the drums, tubes, circulating pipes, etc., as well as a large marine-type boiler, 14 ft. long by 11 ft. 6 ins. in diameter, constructed for 180 lbs. working pressure, under the supervision of Messrs. Kennedy & Jenkins, consulting engineers, 17, Victoria Street, London, S.W., for the Ipswich Corporation, and which is awaiting delivery instructions.

Messrs. Alfred Herbert & Co., Coventry.

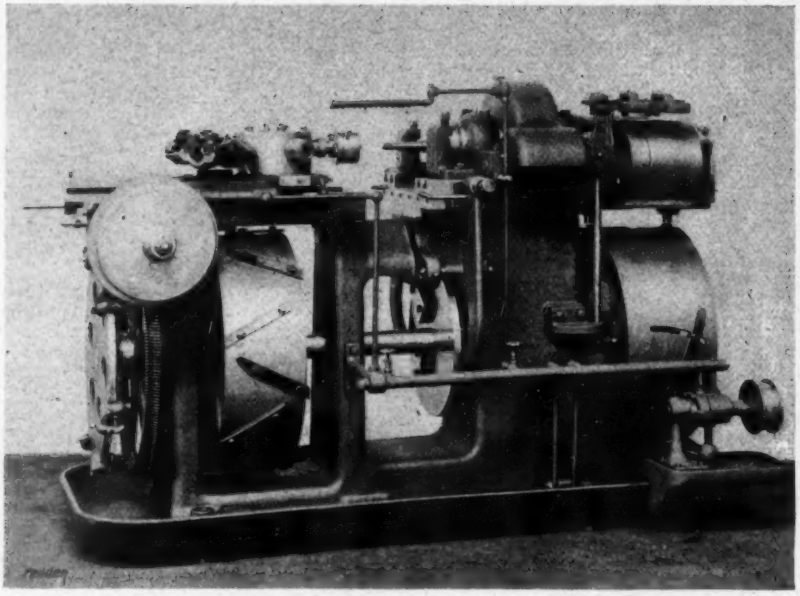
This firm have, as usual, a very fine show of automatic and semi-automatic tools in operation upon actual work, some of which are quite new, or embody recent improvements. Of these is the No. 2 automatic screw machine, with special sliding turret for producing engine studs, illustrated below. This machine differs from the standard type of automatic machine, in that a cross-sliding turret carrying two tools—namely, a box tool and the die-head—is substituted for the ordinary rotating turret. The studs are made from ordinary black bar, and at the first operation are turned, screwed, ended, and cut off. For finishing the second ends of the studs the machine is fitted with a magazine, which feeds the previously cut-off studs automatically through the spindle of the machine from the back into the chuck, where they are screwed and ejected. The machine is extremely rapid in its operation, and is, we think, well worth examination as representing the latest practice in this class of work.

The No. 3A automatic screw machine is also noteworthy. This machine admits 2-in. bars through the spindle, and is employed producing 1-in. diameter hexagon-headed bolts from hexagon bar, and also certain other work of a like nature. It is fitted with a standard set of cams and tools for producing any ordinary engineer's bolts, studs, pins, collars, bushes, etc., from the bar. The machine in operation is making bolts.

The No. "0" automatic screw machine is at work producing a small stud or button from brass bar. These buttons are given away as souvenirs, and are intended to represent, on a small scale, the turrets to Messrs.



THE WOLVERHAMPTON EXHIBITION: MESSRS. ALFRED HERBERT'S NO. 2 AUTOMATIC STUD MACHINE.



THE WOLVERHAMPTON EXHIBITION: MESSRS. ALFRED HERBERT'S NO. 3A AUTOMATIC SCREW MACHINE.

Herbert's hexagon turret lathes. A very complete and ingenious set of tools is in use on this machine, as the operations include not only the boring and the forming of the button, but also the milling of its hexagon faces and the boring of the holes in the centre of the faces. In addition to this, the name of the firm is rolled upon the button. The whole of these operations take place without stopping the spindle of the machine. This machine shows an extremely interesting example of the great ease with which pieces of very difficult shape can be made upon automatic machines with properly designed tools.

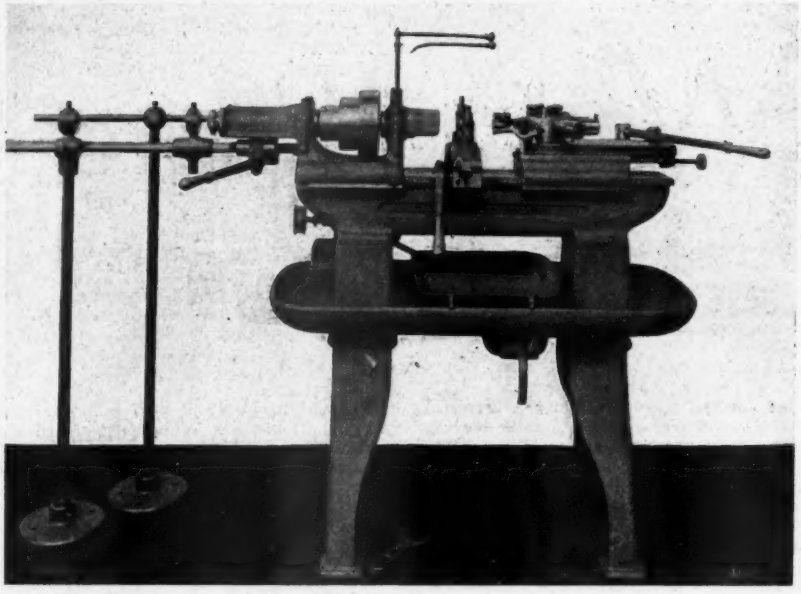
Among the capstan lathes, that designated No. 1 calls for particular attention. This is a small machine admitting bars up to ½-in. diameter. It is at work in the Exhibition, producing brass screws from the bar for a prominent Wolverhampton electrical firm. There are several novel features in this machine, which have been introduced for the purpose of enabling it to do very high speed work. The design of the turret mechanism is such that it will stand the very severe shocks which always accompany the use of such machines without damage, and the whole of the turret mechanism is entirely dust proof.

It has been found that on high-speed brass work the fine dust is very injurious to the turret mechanism, and this has induced Messrs. Herbert to so modify the design as to entirely exclude all dust.

It should be noticed also that special arrangements are provided in the headstock for enabling the spindle to run at high speeds. The lubrication of the spindle is done by an improved method, and the cone pulley is fixed to the spindle without the use of keys, thus enabling perfect balance to be obtained.

The adjustment of the automatic chuck for diameter is made by knurled nuts without the use of spanners, and the covers are arranged so as to be easily lifted off without slacking any screws. The design of the frame of the machine is such as to give very great stiffness, and special attention is directed to the liberal pans and trays which are fitted.

A vertical milling machine of an entirely new design, and never exhibited before, is also shown, and forms the subject of the presentation plate.



THE WOLVERHAMPTON EXHIBITION: MESSRS. ALFRED HERBERT'S NO. 1 CAPSTAN LATHE.

It is an extremely rigid machine, and special note should be taken of the feed mechanism, which is of very novel type, being contained inside the body of the machine.

The form of the knee and tables is such as to enable very heavy milling to be done, and the design of the machine has been so arranged that all the operating handles are under full control of the operator without moving from his position at the front of the machine. This is a great point in milling irregular forms in which it is necessary to have two motions in operation at the same time.

Messrs. Herbert show numerous examples of other machines of standard pattern at their stand, which occupies a space 60 ft. long by 20 ft. wide. Power is supplied by a 20 h.p. motor, by the Lancashire Dynamo and Motor Co., the shafting and pulleys being by Messrs. George Richards & Co., Broadheath.

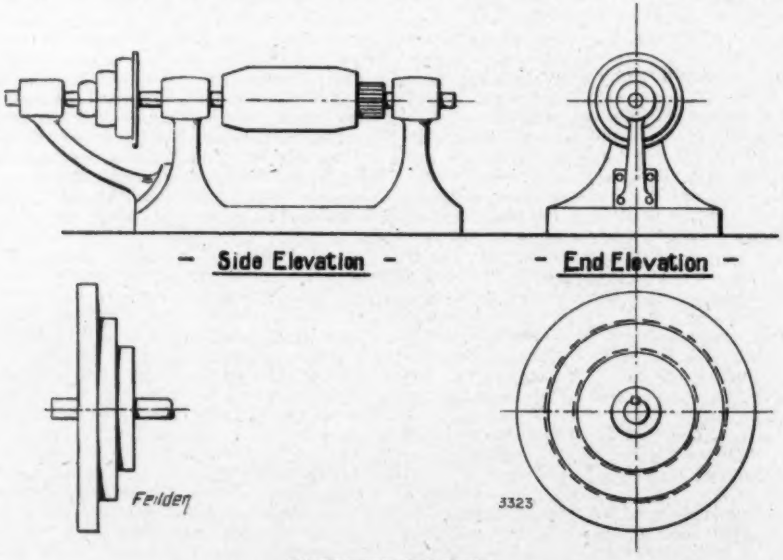
(To be continued.)

Workshop Practice

Practical suggestions for this section are invited, which, if accepted, will be suitably paid for. Wherever possible, drawings should accompany the contribution; rough sketches will suffice. Nothing will be too poor for a careful inspection. See important announcement in advertisement pages.

❀ ❀ ❀

The Faulty Design of a Motor is corrected by the addition of a side Bracket.—Having constructed a special boring machine, with a 2½ h.p. motor mounted on the bracket which carried the gearing for driving the boring bar, the power being transmitted by a short belt running on a three-coned pulley, as shown in the sketches, the driving was found to be very unsteady. The distance between the centre of the motor shaft and that of the shaft driving the boring bar was only about 3 ft., and as the motor ran at a speed of 1,200 revolutions per minute, the reducing gear had to be about 5 to 1, and the belt very tight indeed. The consequence was, when the machine was at work the motor shaft sprung a good deal, causing the commutator to wobble, and gave rise to a good deal of sparking. The sparking at the brushes caused them to heat very much, and in addition the motor spindle at the commutator end did not run true. It worked against the upper side of its bearing, wearing the latter into the form of an oval. The motor shaft was only ⅞-in. diameter. Fortunately it was sufficiently long to allow of the addition



FAULTY DESIGN OF A MOTOR.

of a small bracket bearing being bolted to the motor frame, with four ¼-in. screws, as shown in the sketch. This supported the shaft and has converted the apparatus from a failure into a success.

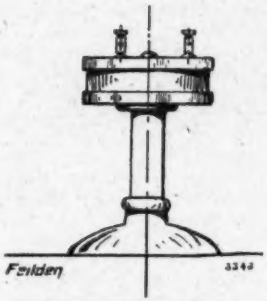
MOTOR SPINDLE.

[NOTE.—Our correspondent appears to have been led into a common error; he has been attempting to do his work too cheaply. In our opinion, if he had constructed the motor on stronger and heavier lines he would have been better off in every respect. We should like to hear from him what the cost of his cheaper design was in time lost, and the cost of putting on the extra bracket and bearing. In our opinion also, he is not quite out of the wood yet. That same trouble may come up again later on, when some of the parts of the machine have worn. It is always tempting to put in a small motor or a small engine to do certain work, but it is always expensive.—ED.]

A Rat sets fire to a Bedroom.—This, again, was in the early days of electric lighting, when it was thought that wood casing was employed for insulating purposes, and that its presence absolved contractors and others who were responsible from the necessity of providing much insulation upon the wires themselves. The wires in this case were insulated with a very small quantity of pure rubber (very much less than would have been put upon a bell-wire by a bell electrician who had had much practice) and a small quantity of cotton; also less than the bell electrician would have used for his bell-wires. The wires also, which fed a lamp in a bedroom, were exceedingly small; again smaller than the bell electrician would have used for his bells. The contractor was a young gentleman who had learnt—or, at any rate, who knew; he said so—all about electricity. He had attended a class or two, at which ladies also attended, and he had always made himself agreeable to the ladies of the class, and was always ready to explain to them everything that was obscure in what some of them considered a troublesome subject. In his own opinion he was fully equipped to go anywhere and do anything—electrically. Unfortunately at the class they had not lectured upon the peculiar idiosyncrasies of the rat, and the ladies of the class, for obvious reasons, did not afford him the opportunity of studying the vagaries of that intelligent animal. The electrical pressure of the service (it was in the early days) was very low at the dynamo, and, owing to the ideas of distribution possessed by our young friend the contractor, the pressure in the particulr bedroom was still less—not sufficient to seriously annoy a vigorous rat, if the rodent was bent upon a certain course which happened to be barred by wires with this pressure in them. The room in which the wires were laid was a very dry one, and it was a very dry summer when the trouble came. The wires, insulated as described, were laid in thin wood casing, which was also very dry, and there was either no partition at all between the wires or it was a very thin one. One day, unknown to anyone, a vigorous rat was in the bedroom, and wished to eat his way through to the next room. The nearest passage was through the partition to which the wires in their wood casing were fixed. The rat nibbled off a piece of the cover of the casing—not a very difficult matter—then nibbled at one wire, stripped it, cut it in two, and went nibbling on. The cutting of the one wire put out the light in the bedroom, but as it was not much used in summer, and as it was not an infrequent occurrence in those days for electric lights to be extinguished for a time, till someone who understood the matter had time to twist the ends of a wire together or perform some equally simple operation, no one troubled. Rats are sometimes slow, but in matters of this kind they are usually sure, and so in due time the rat nibbled the middle rib of the casing through, leaving it and the outer piece in that more or less jagged state that follows from a rat's teeth. In due course he came to the other wire, which he stripped and parted, and in his efforts and various motions in getting through the hole he had made, he drew the two ends of the wires, the opposite sides of the circuit, into contact. A short circuit followed immediately. The wires almost instantly burnt themselves clear and an arc formed between them, which became larger and which, assisted by the heat in the wires, ignited the casing, the paper on the walls, and was fast getting hold of the partition between the two rooms through which the rat was boring when, fortunately, the smoke was seen, the fire put out, and the cause discovered. The rat met his death by cremation, but it might be a consolation to his family to know that he died in a good cause—the education of contractors in the proper method of wiring premises for electric light.

A Magnetic Tool Holder.—Quite a new idea is the magnetic instrument and tool-holder (for the convenience of draughtsmen, whose instruments it holds when not in use), consisting of two circular plates, about 4½ ins. diameter and a quarter of an inch thick, connected by a centre core about 1½ in. diameter. The space between these two

plates (about ¾-in. in width) is filled with No. 27 double cotton-covered wire, the two ends leading to the two binding posts on top of the holder. Both the plates and core are of tool steel, and hardened. After having been connected in series with an arc lamp of 220 volts for a few minutes, the holder becomes a permanent magnet, proving an inestimable boon to the worker, whose tools invariably get in his way.

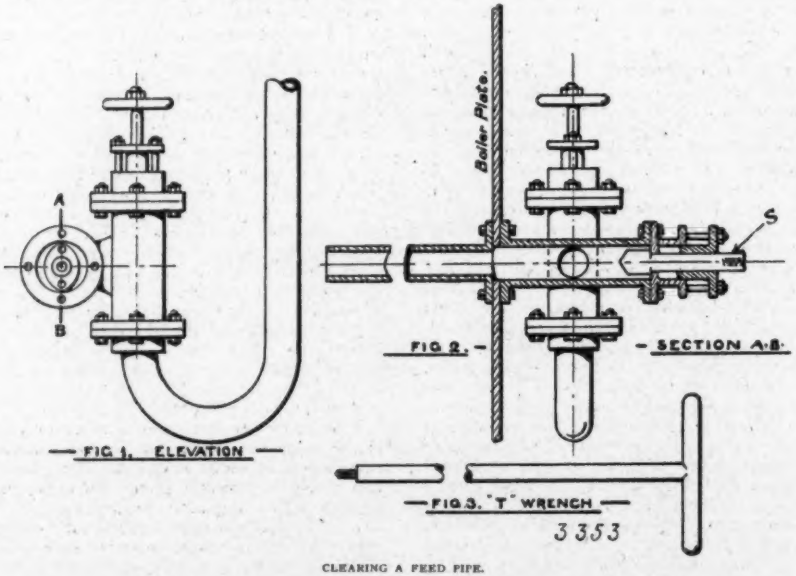


MAGNETIC TOOL HOLDER.

Clearing a Feed Pipe.—We have experienced great difficulty at our works by the corrosion of the feed-water pipe, at the end inside the boiler, and this often bent the pump-rod and ended up by having to blow off the steam, take the blank flange off the check valve, and rimer out the pipe before being able to start again. This was a serious matter, and to remedy it we made the arrangement as illustrated at Figs. 1, 2 and 3. The check valve was of the ordinary screw-down type with a blank flange on the front. This we replaced with stuffing-box and gland, and to the latter was fitted a drill as shown, turned to a shoulder at the front end, and bored and tapped with a ⅝-in. Whitworth thread at the other, to receive the end of the T-wrench shown at Fig. 3. The drill enclosed by the gland was always in the position indicated except when in use; it is out of the way, and presents no obstacle to the water passing into the boiler. The gland is packed with asbestos, and the shoulder on the drill prevents it blowing out. Whenever the pump is found to be working hard, we insert the wrench—which should be plenty long enough to reach the pipe-end—into the drill, turning in the direction to tighten the screw, both in going in and out. This prevents unscrewing, and it is quite easy to feel when the drill has cleared the pipe.

J. SEABOURNE.

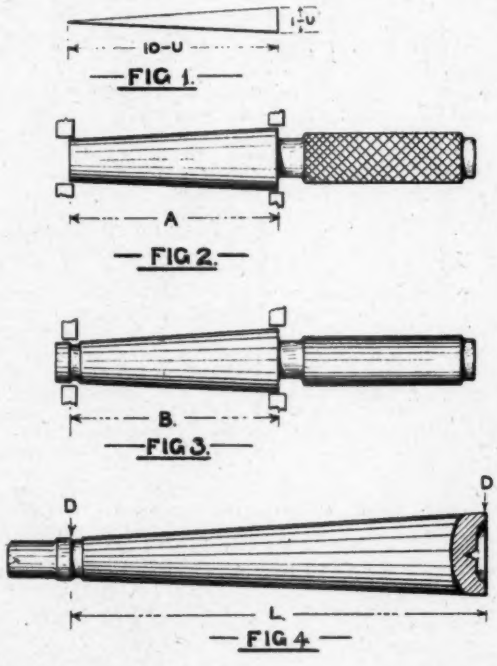
[We think a square on the drill at *S* would be an advantage when releasing the wrench.—ED.]



CLEARING A FEED PIPE.

Making Taper Gauges.—No doubt all those who have had some practice in mechanical engineering know that it is more difficult to make a certain taper bore or spindle accurate, than a parallel one. Again, on the other hand, it should be known that in certain cases the extra cost of producing such a taper is well expended. In order to obtain good results, accurately made gauges are of utmost importance. The following is a practice of mine, and should enable any good mechanic to obtain satisfactory results by means of fairly good tools. I, perhaps, may mention that the indexes of grinding machines and lathe must not be relied upon in the making of such gauges. Any taper may even, if given in degrees, be expressed more definitely by stating how many units there are in length before the taper increases one unit in diameter; for instance in a taper of 1 in 10 there are ten units in length before the diameter increases one unit, as shown in Fig. 1. In Fig. 2. is shown the usual form of taper gauge. There would be no difficulty in measuring the length *A*, but it would be more difficult to accurately measure the difference in diameter; as the measuring instrument would have to embrace the small diameter for a certain distance, and, as only the points of the same could be used, errors would be unavoidable. By making the gauge as shown in Fig. 3, we measure under better conditions, and greater accuracy can be obtained. If there is no objection to the groove, it may serve as a working gauge, particularly if it is only made for the convenience of an odd taper. For a standard taper, no doubt, it is best to keep this first gauge for reference only, which may then be made as shown in Fig. 4. An internal gauge, as shown in Fig. 5, may next be made from it and the working gauge Fig. 2 copied from the internal gauge. The length *B* in Fig. 3 may be measured by means of a slide gauge, jennies, caliper, and rule; whereas gauge Fig. 4 may be stood on a surface plate and measured by means of a scribing block and steel rule or a height gauge. In order to obtain good results these gauges should not be made too long, as this is conducive to springing in grinding or turning; the centres should be lapped after hardening; the emery wheel must be free cutting and the grinding machine well adjusted.

(Prize divided.) H. HELLFRITSCH.

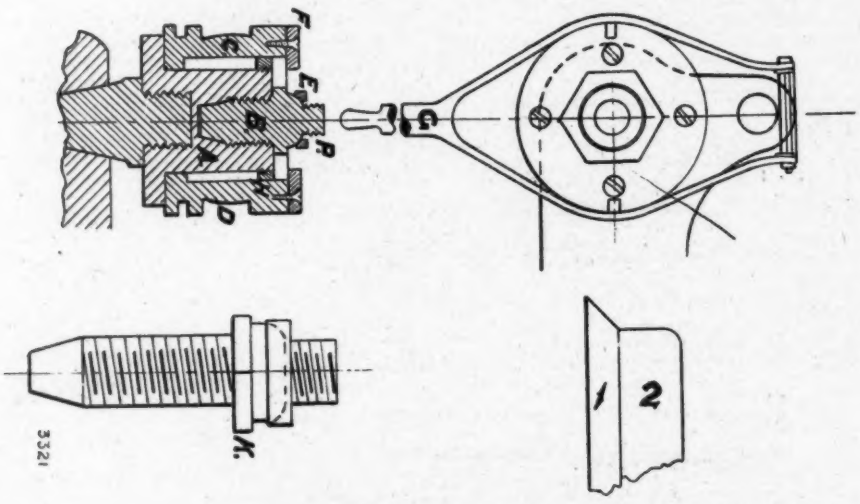


MAKING TAPER GAUGES.

Nut-facing Attachment *A*, driven by lathe spindle, carries nut-facing mandrel *B* at about 120 revolutions per minute; and while in motion the nut to be faced is put on the mandrel at point *P* up against the washer *E*, which by a ball motion gives way to the roughness of the forged nut, allowing it to be faced up true to its own thread. Two tools are fixed and set in the slide-rest, as shown at Figs. 1 and 2, and by running down the surface the nut is faced and chamfered. Section *C* is a sliding sleeve

driven from an independent pulley belted round the space *D* just as fast again as the spindle—that is, 240 revolutions; and screwed to its face are fixed collets *F*, suitable to the size of nut to be faced. *H* is a left-handed nut screwed on *A* to keep *C* from coming too far, and the outside of *H* is the same diameter as the inside of *C*. During the facing operation the sleeve and collet stand just behind the nut, and as soon as the tools return by drawing the lever *G* the nut is instantly whipped off. Rollers running on pins in lever *G* in the recess will run far easier than pins alone. The mandrels are changed by the use of a carriage cup key, which fits on the hexagon part of the mandrel *K*.

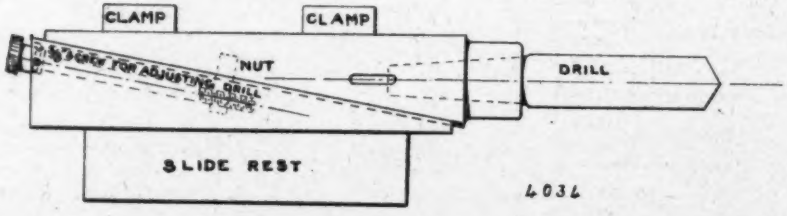
J. H. B.



NUT-FACING ATTACHMENT.

A Twist Drill Holder.—An improved form of twist drill holder is shown at Fig. 1, and consists of two inclined planes sliding on each other, and provided with a tongue and groove to prevent side slip. A screw with a knurled head engages in a nut set in the top piece, thus forming a means of adjusting the holder to the exact height of lathe centre. In making this useful accessory the inclined planes are first machined, then clamped together, and the end turned down as shown. This allows the holder to be run in a stay, while the hole is bored to the regulation taper to receive the drill shank. A cotter hole drilled at the end of the bore admits of the drill being forced out, and the fixing of the nut and screw completes the holder.

SPIRAL.



A TWIST DRILL HOLDER.

The Practical Construction of the Marine Propeller *(Continued from page 371.)*—It is, perhaps, at this stage that some explanation should be given relative to the method of setting out the angles of the blade as required for workshop reference.

In order to determine the angle of the blade at any point in relation to the axis, either when building the layers of timber for a whole pattern, or making the races for a loam-moulded one, it is necessary to set out an elevation of the blade—if possible—to full size dimensions, and as follows at Fig. 15.

On a horizontal line, *C*, as the centre or axis of the shafts, erect a perpendicular *P.P*¹. This line represents the driving or working face of the screw. From *P*¹ set off on *C*, the distance *D*, which is obtained by *dividing the required pitch by twice the circumference of unity*, or as an example, a propeller of 12 ft. 0 in. pitch, would have the distance *D* 22·89 ins. from *P.P*¹, on the line *C*, this being the quotient of 144 ins. divided by 6·28. On the line *P*,*P*¹ equal distances should be set off from *C*¹ to the tip of the blade. Then, lines drawn through these points to *D* show the correct angle of the blade at each division, *R* being the angle at the neck and *T* the angle at tip. The angle at any point may be found by multiplying the radius at this point by 6·28 and using the product as a divisor into the known pitch, the quotient being the tangent of the angle. Similarly the pitch can be found—in the case of a broken propeller—by the converse operation of multiplying the radius at any convenient point by 6·28 and this product by the known angle, which may be ascertained by measurement.

This method is applicable to the measurement of a *true* screw only, as *A* Fig. 15, those of variable pitches taken seriatim, are calculated as follows:—*B* Fig. 15 is a gradually increasing pitch from *neck to tip*. Let distance *a* equal the least pitch, distance *b* the greatest pitch as found by preceding rule. Divide the distance from tip to root into any number of equal parts, and the distance *a* to *b* into the same number as *c*, *d*, *e*, *f*, *g* and 1, 2, 3, 4, 5, draw line 1 to *c* equal to angle at root, *g* to 5 equal to angle at tip. The intermediates 2 to *d*, &c., are equal to the angle of the blade at that part. *C* Fig. 15 is an *increasing pitch longitudinally*. Let the distance *a* equal pitch of leading edge, distance *b* equal pitch of following edge obtained by the same rule. Set off these distances on line *C* and divide distance from tip to root as before into any number of equal parts, then a line drawn through *a* to any point on the perpendicular represents the angle of the leading edge of the blade at this point, and a line drawn through *b* to any point represents the angle of the blade for the following edge. *D*, Fig. 15, shows the blade face thrown outwards, or, as it is termed, going astern. The angle at any point *P* on the blade is obtained by erecting a line perpendicular to the axis and touching the point *P*. From this set off the distance of the pitch as before on line *C*, as *F*, then a line drawn through *F* and touching *P* equals the angle of the blade at that radius.

The preliminaries of moulding consist of setting the bottom plate on cast-iron stools about a foot high to better enable the moulder to make the superstructure secure by bolts, etc., and also to allow of the application of the crane chains for lifting purposes. The plate is located under the loam spindle, which is supported by a large wall bracket

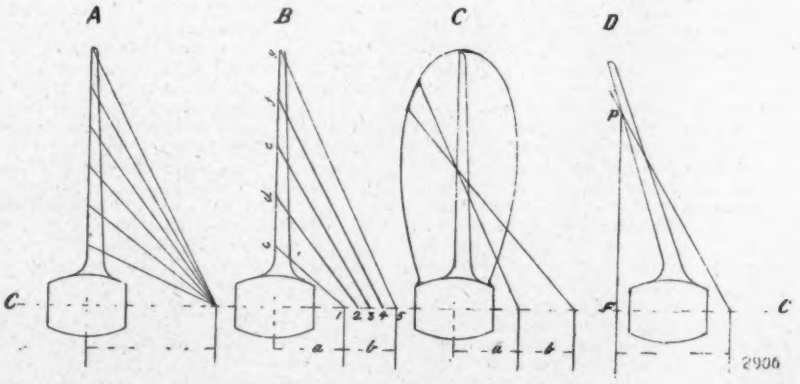


FIG. 15.—ANGLES OF BLADES.

capable of being swung into any convenient position, the end of the spindle resting in a footstep placed on the floor directly under the hole in the plate. The spindle is tested by means of a plumb-rule, and the plate set with a spirit level. It may be of interest to some of our readers to inform them that open sand plates used in connection with this class of work is made by the loam-moulder to suit the several jobs for which they are used, and the term *open sand* is applied to the rougher form of castings which have their top surfaces uncovered. The moulds for this type of casting are usually prepared in the floor of the foundry and without pattern, the moulder making a rectangular plate by means of a couple of straight edges, or striking out a circular one with a pair of trammels, a piece of timber to form the lugs, and sometimes provided by the magnanimity of the pattern-maker with a segment for making-up purposes. Open sand plates for this purpose are roughened on the surface with "prods," or projections like hobnails made in the mould with the finger end or a short stick, and thus transferred to the casting. Similarly pieces of furnace coke are employed for the same purpose, viz., to increase the adhesion of the loam.

The thickness of open sand castings is regulated, not by the depth of the mould, but by a number of channels cut at intervals on the edge of the mould. By this arrangement a plate of any thickness less than the depth of the mould can be made, as the edges of the "flow off" channels are cut to the depth of plate required.

The plate having been fixed in position, the surface is first "swabbed" with clay-wash, and a layer of bricks bedded in and cemented together with the so-called mortar.

A thickness of loam about ¾ ins. is then spread over the surface of the bricks and on the outside edge, and the board swept round. As the operation proceeds, the moulder makes up with a further supply, any part of the face where the board has failed to form a surface, again sweeping it over to remove any superfluity of material.

The varying heights are prepared with an extra course of brick, or what are termed loam bricks are interposed as the occasion requires.

These latter are made of various forms and thicknesses, and may be compared to cores. They are used to make up surfaces where the ordinary form of brick mould would be inconvenient, or to form projections or dummy parts to be removed when finishing the mould. The board, Fig. 11, is then attached to the gudgeon or strap which is free to revolve round the spindle, and is kept to a fixed height by a collar on the underside.

After the loam has become partially dry or stiffened, the neck and tip-races are set by the pattern-maker in their respective positions on a line drawn through the centre across the face of the loam, the number of lines corresponding to the number of blades. These are secured in position by a few wood screws driven in the loam, with some pieces of pig-iron weighting them down. Previous to the setting of the "races," the board, Fig. 13, has been attached to the spindle, and a dummy boss formed. The intervening space is then filled in with brick, and finished with a coating of loam, strickled off to the incline formed by moving the straight-edge down the inclines of the "races," the neck being finished into the boss with a large hollow or fillet. This portion of the mould is then dried, and, blackened with a wash of liquid plumbago, a line is marked through the centre, and the pattern-maker then proceeds to fix the *section* pieces.

These are made from timber ½ in. or ¾ in. thick and, as implied, represent the sections of the blade at given distances from the centre. These are held on the surface of the loam by a few sprigs pushed in against both sides of the strips. The spaces between are then filled in with black sand and strickled off to the convex edges of the strips. A thin lath is used for the purpose of marking a line which represents the edge of the blade on each side, the lath touching the end of each section piece. Similarly from the convex surface, as from the flat, the neck is finished into the boss by large fillets formed with sand packed, strickled or sleeked to a finish. The black sand part of the mould is then freely sprinkled with parting sand which serves the same purpose as blackening the loam, viz., to separate the surfaces of the top and bottom faces of the mould. This portion of the mould is now ready to have the top part formed, as follows. As the inclined plane is of varying angle from the centre, and the use of a flat plate would be out of the question, the following expedient is usually adopted. An L shaped open sand-plate is made, on the vertical leg of which is cast a number of projecting pieces or lug shaving a cored bolt-hole through each. A second plate is also made of a segmental form coincident with the outside of the loam surface beyond the tip race. A number of staples, similar to the handles of a moulding box, are cast in this plate, and equal in number to the projections cast on the L plate. Feet—with bolt holes—are also cast at each end of the segment plate, and these must

be vertical with the *horizontal* face of the mould. A number of bearers or cast-iron bars are made with a bolt hole in one end and these serve to secure the bars to the lugs on the L-shaped plate. A thickness of loam is then put over the face of the mould, and the L plate set in a vertical position against the end of the brickwork forming the incline. This plate together with the segment plate and bearers are well clay-washed, bedded in the loam and bolted to the lugs of the vertical L plate. The segment plate and L plate being bolted together at the bottom end, with a cross-bar connecting them at the top of the incline, the bearers being threaded through the staples bolted to the L plate, and held with wooden wedges at the other end. Through this grid or frame the loam is now packed to about ¾ in. thick over the entire surface, the spaces between the bearers being filled with pieces of brick, while the bearers themselves support a few courses of the same, and forming the top part of the mould. As the inclined buttress of brickwork and loam, forming the faces of the blades are partially detached, a separate grid is required for each. After the loam has somewhat stiffened, the top parts are lifted away and the dummy portion of the mould forming the blade is cleared off. After stove-drying and blackening, the necessary preparations are made for casting, the runners being usually located on the boss and the risers at the highest points of the mould. In the making of two-bladed propellers, some firms adopt a method of striking up the blade surfaces simultaneously, by using two sets of "races" with a double board attached to a double ended "gudgeon," supported by cords passing over grooved pulleys, fixed on a cross-bar at the top of the spindle. Balance weights at the ends of the cords, provide an easy movement up and down the spindle.

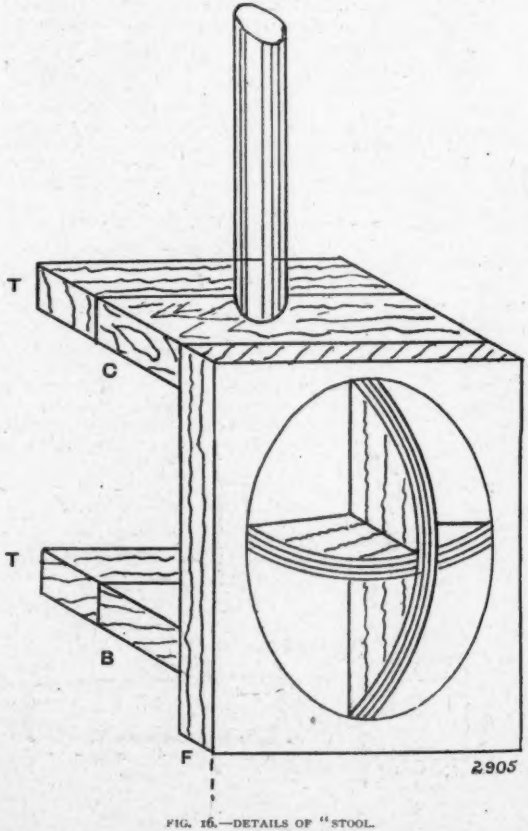


FIG. 16.—DETAILS OF "STOOL.

Having described the whole of the necessary details in the solid type of propeller, we may now pass to the making of the single blade, a number of which are bolted to a central boss. The construction of the strickles, races and section pieces are precisely the same, the one exception being the method of forming the part boss at the neck end of the blade. For this purpose a "stool" or fixing, Fig. 16, is required made of timber screwed firmly together. The edge of the cross bars, *CB*, represents the centre line of the loam spindle, and the distance from this to the face *F* is coincident with that from the centre of the propeller boss, to the face of the blade boss. Two pieces of timber *T* to form caps, are screwed on the cross bars through which are cut circular holes fitting the loam spindle. The portion of the boss is formed on the stool, by sprigging pieces of timber similar to the section pieces on the face *F*, at a given height from the loam bed on which the stool rests. These pieces are usually cut to the line with the band saw and cleaned up on the convex edge, no regard to

thickness being given. Six or eight pieces are generally enough to form the contour of the boss, the intervening spaces being filled with black sand or loam. During the operation of striking up the inclined surface representing the blade, the stool is swivelled out of the way, and afterwards brought into position for finishing the neck into the boss.

Together with the other portion of the mould it is blackened or in other ways prepared for parting. After drying the whole of the top, part is covered with a coating of loam, which supported with grids and brickwork constitute the mould. The casting is then trimmed up and used as a pattern from which to make either green or dry sand-moulds for the working castings.

In concluding the article a few comparative figures may be of interest, as illustrative of the progress made in marine engineering during the last half century. In 1848-50 the *Rattler*, with engines of 428 i.h.p., attained, with a screw of 10 ft. diameter, a speed of ten miles per hour. In 1894 the Cunard liner *Lucania*, with engines of 28,500 i.h.p., and propellers of 23 ft. 6 ins. diameter, 34 ft. pitch, made an average of more than *26 miles per hour*.

Some idea may be formed as to the enormous cost of the modern propeller from those fitted to the Cunarders *Etruria* and *Umbria*. The diameter is 24 ft 6 ins., 33 ft. 6 in. pitch, with a blade surface area of 216 square feet, and a total weight of 29 tons for the four blades. At a cost of £120 per ton for the Manganese bronze, out of which they were cast, the total of the four blades reached a sum of £3,360.

In addition to this, the cast-steel boss to which they were bolted cost £1,000, making a total of nearly £5,000 for *each* propeller as completed ready for fixing on the shaft.

W. H. W.

Improved Cutter Arbor.—Illustrated at Fig. 2 is a handy form of cutter arbor. It was made to take the place of the old style (Fig. 1) with screw at the end, the head of which invariably broke off when used a few times, it being too weak to stand the pressure put upon it. In the improved type (Fig. 2) the part *A* is made taper, and the threaded part *B* must be less than the smallest diameter of *A*, to allow the cutter to go on; and the largest part of shank *C* must be less than the bottom of thread, or otherwise the thread will have to be cut along the shank that the nut *E* may be screwed on. The work to be done when this arbor was first made was a V slide, forming part of a machine, and which had to be milled on both angles and bottom. Whilst cutting, the head of the screw of old arbor (Fig. 1) broke off, and the cutter dug into the bottom of slide, which necessitated another cut being taken over the surface. The thread of the arbor is left-handed, in order to stop any tendency to work loose; and as it revolves in the same direction as a drill it tightens itself. The nut is used to withdraw the arbor from the socket; by undoing and screwing it against the end of socket it will force the arbor out, which does away with the usual method of slotting the socket to allow the arbor to be driven out with a wedge. It is not necessary that the cutters shall be bored taper, as by making a split bush with a taper hole to suit the arbor at *A*, and the outside diameter to fit the hole in cutter—the length being about the same as bearing part—and allowing the key *D* to stand above the outside diameter of bush for driving purposes, any cutters with parallel holes can be used on it. Since the introduction of this form of arbor, and in conjunction with taper-bored cutters, we have experienced no difficulty or trouble when taking the heaviest cut.

(Prize divided.)

C. H. G.

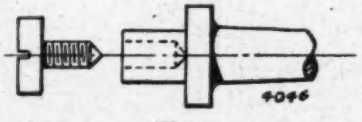


FIG. 1.

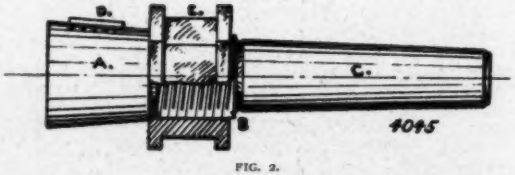


FIG. 2.
IMPROVED CUTTER ARBOR.

A Valve Trouble.—On starting up one of our electric-light engines the other evening we soon noticed that something was wrong, for at half load the engine seemed not to be getting sufficient steam. As it was impossible to stop just then, we kept it running as heavily loaded as it would carry until we could shut down. After stopping, a thorough examination was made, and the fault dis-

covered. The steam-valve between the engine branch-pipe and main steam-pipe had been shut that day while some joints were being made; and when it was opened again the toes of the valve had fouled the seat (which is a brass ring set in with neither screw nor pin to hold it), and drew it out, so that, while the valve seemed to be full open, it was almost closed. What made the fault more difficult to find was that the valve and seat would work in with the spindle when turned and close the valve, but on being opened again the seat came with the valve. After filing down the toes a little, so as to clear the seat, we replaced the seat and valve, and tried whether the valve would do without the seat being fastened in or not, but the engine had not been running ten minutes before the seat came out again, and completely closed the valve. J. A. McC.

[This is a somewhat unique experience, as the seatings are usually made a driving fit. —ED.]

An Improved Tee Pipe.—It frequently happens when setting up a system of steam pipes that a T-piece has to be introduced such as is shown in Fig. 1, and it is found difficult to make the joints between the flanges and the T-piece *A* (Fig. 1) tight to high-pressure steam — this, for various reasons, such as the nipples being a little slack, the faces being not quite square, and the impossibility of properly caulking, owing to the awkward position of the flanges, etc. This difficulty can be efficiently overcome by substituting short pieces of pipe about 9 ins. long for the nipples, as shown in *B* (Fig. 2). It is then a simple matter to screw the pieces of pipe a tight fit for the flanges, and if necessary a caulking tool can be easily got in at the joints. Whereas it is sometimes necessary to even braze the joints to make them steam tight, when they are made as in Fig. 1, but when made as in Fig. 2 there is seldom the trace of a leak, though the pressure in the pipes is sometimes as much as 300 lbs. per square inch. FITTER.

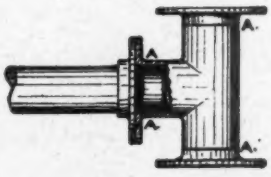


FIG. 1.

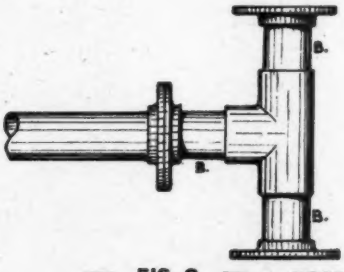


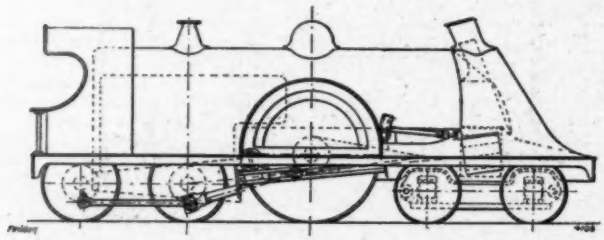
FIG. 2. 3353

AN IMPROVED TEE PIPE.

INDUSTRIAL PROGRESS

ENGINEERING NOTES FROM ALL SOURCES.

Suggested New Type of Locomotive.—In a recent letter addressed to our contemporary, *The Engineer*, Mr. David Joy, the designer of the well-known valve-gear which bears his name, makes, in discussing the Marshall valve-gear, about which so much has recently been heard, an interesting suggestion for a new type of locomotive, a scale sketch of which is reproduced. It is really intended to show to those who maintain that the compound system for railway work will not suit the various and varying conditions met with, owing to the rising and falling gradients, that a locomotive could be constructed so as be always kept approximately near the condition of highest efficiency with greatest economy. To accomplish this, Mr. Joy's proposition is to construct an engine capable of running either compound or simple: the former when maximum efficiency is required, as when climbing a bank; the latter when speed is the chief consideration, as in running on the level or downhill. The engine is compound, but has two distinct sets of cylinders and wheels, the four coupled driven by a pair of outside cylinders at boiler pressure, passing the steam forward into a pair of low-pressure cylinders between the frames, driving the large pair of single drivers. In this combination the engine is capable of exerting its greatest power, and, at the same time, utilising steam in the most econom cal manner, particularly in starting a heavy train facing a long rise. The summit being reached, and with the great power at command a fine speed having been attained notwithstanding the rise, steam is shut off from the high-pressure cylinders which immediately cease action, like the feet on a free-wheel bicycle. As the small set of wheels are mounted on the free-wheel principle, they then roll on only but continue to carry weight, while live steam is passed to the large cylinders, which alone drive their pair of wheels and continue to haul the train, which, however, is already at, or near, its top speed. No difficulty should be found with this arrangement, and by careful handling in maintaining, according to ground and gradients, a maximum speed. The idea seems to be a practical one for securing maximum efficiency with economy, and is worthy of being carried out.



JOY'S PROPOSED LOCOMOTIVE.

Triple Electric Furnace for Iron Smelting.—M. Harmet, who claims that his method of making iron reduces the cost by more than 10s. per ton, employs three contiguous furnaces, one for smelting the ore, the second for effecting its reduction, and the third for completing the operation. The first furnace is of circular section, with the inside increasing in diameter from top to bottom for facilitating descent of the materials. The hearth is inclined toward the second or reducing furnace, whose form is such that the gas can escape freely, so as to enter into combustion and reach the mouth, which is quite open. The fusion of the oxide on the hearth is effected by the gas that issues from the reducing furnace and by a supplementary source of heat which is necessary for regulating this fusion, such supplementary heat being furnished by one or more pairs of carbons entering the furnace above the hearth. The second furnace consists of a

shaft of circular section, closed above, into which coke, coal or other reducing substance is charged; and this shaft is kept full, so that the pressure on the coke at the bottom obliges it to penetrate like a column on to the reducing hearth. The latter is inclined so as to receive the molten oxides from the first furnace; and, in addition to the opening by which the reducing substance is charged in, this furnace has a second by which all the gases are disengaged, and also other openings for the passage of the carbon electrodes. There are, moreover, two tap-holes, one for the molten metal and the other for the slag, while the slag and the metal cannot make their way out without passing through a thick layer of incandescent reducing material. As the reduction of the oxide absorbs more heat than is produced by the transformation of the coke into carbonic acid, electric current is resorted to for supplying the insufficiency of caloric. The third or regulating furnace is a chamber of circular section with the usual openings, heated by electric current, the circular form having great advantages as regards construction and maintenance of the refractory lining. Without being a new method, observes M. Robert Pitaval in the *Echo des Mines et de la Métallurgie*, M. Harmet's invention is the valuable contribution of a clever metallurgist to the study of electro-metallurgy.

The Principal Defect in Water-Tube Boilers.—M. Bertin, the distinguished naval constructor of the French Navy, has, according to the *Glasgow Herald*, recently given his views regarding the adoption of the Belleville boiler in our Navy. In the opinion of this expert, it would have been more prudent to begin with a combination of this steam generator along with the old cylindrical type; but this advice, peculiarly enough, is not based on the possible fuel economy realisable at low powers, but rather on the ground that the change, being more gradual, would have enabled the men to be educated as to the working of the boilers more fully and with more care than was possible when so many were fitted in the first instance. The principal defect urged by M. Bertin of practically all the better known types of water-tube boilers is the absence of a combustion chamber. The economiser in the Belleville boiler has reduced the volume of smoke emitted by the funnels, but has not overcome the trouble due to deposits on the tubes, and thus the boilers have to be cleaned out at frequent ntervals. Boilers with vertical tubes do not give the same trouble, but fuel combustion is not so perfect, and therefore the economy is lower. The chief desideratum in M. Bertin's experience is a combustion chamber, and this view is widely held; and the Director of Construction of the French Navy, having inspected the boiler of Mr. James Weir, at Cathcart, pronounces most favourably upon it, as it has such a chamber, and thus there is neither smoke nor soot, no cleaning is necessary, and, combustion being perfected, the fuel consumption is greatly reduced, although the rate of evaporation is high. The Admiralty Boiler Committee are also interested in the boiler, and exhaustive trials will likely be made by them.

A New High Speed Record.—Officers of the Chicago, Burlington, and Quincy Railroad, have confirmed the record of a remarkable run, of which so much was made in the railway Press of the States, made by a train on the Burlington and Missouri Railroad between Eckley and Wray, Colo., which establishes a new world's record for a run of 14 miles and over. The distance between these two towns is 14·8 miles, and it was covered in exactly nine minutes, or at the rate of 98·66 miles an hour. The train left Denver 10 minutes late, having to wait for a California sleeping car. A heavy wind prevailed from Denver to Akron, a distance of 112 miles, making the train 30 minutes late, leaving Akron (7·17 p.m.). When behind time it is customary for trains to run from Akron to Wray, 54 miles, at a speed of 70 to 75 miles an hour. Eckley, 39 miles east of Akron, was passed at 75 miles an hour, and, as above stated, the time from Eckley to Wray was nine minutes. The time was taken by five separate watches including the conductor's, in the hands of as many men in the observation car, and all watches agreed as to time. The train consisted of a mail car, baggage car, two reclining chair cars, three sleeping cars, a dining car, and a private car, nine in all. There is a down grade from Eckley to Wray, the maximum being 32 ft. to the mile. There is one curve of 1.7 deg. The engine was B. and M. R. No. 41. It is a 10-wheel engine, 19 × 26 in. cylinders, class K-4, with 72-in. drivers. The weight of the engine is 156,600 lbs., and of engine and tender 254,500 lbs. The heating surface measures 2,430 sq. ft.; and grate area 30 sq. ft.

Cotton-seed Oil for Laying Dust.—Trials on a large scale made with this oil at the Vienna Veterinary Institute, have given favourable results in laying and fixing the

dust, although the cost is rather high, as five kilograms are required per square metre (say 10 lb. per square yard) per annum, largely compensated, however, by the better preservation of the floor. The floors were only coated with the oil twice in the course of a year. The class-rooms, which are frequently used, only required sweeping with a hard broom every week, and no dust was found to rise, while that on the furniture was almost imperceptible. The same was noticed in a room that had been unoccupied for five weeks and had not been swept. The Commission charged with the trials recommends the use of this method for all localities that are much frequented, like lecture-rooms, drill-halls, gymnasia, guard-rooms, public offices, and places that should be carefully kept free from dust, such as libraries and laboratories. The oil must not, however, be employed for hospitals, because the infectious matters should be constantly renewed instead of being fixed to the floor, observes the *Moniteur Industriel*.

THE CARNEGIE MEDAL.

The Longest Stone Arch.—The longest stone arch bridge in the world is under construction at Luxemburg, Germany. It will have an arch span of 277·65 ft. It is of novel design, being, in fact, two narrow parallel arches separated by an open space of 19·41 ft., which is bridged over with a platform of steel and concrete for the roadway. This plan saves in weight and in material, and also in time of construction. The height of the arch is 137·76 ft. The stonework is not solid, there being spandrel arches carried on the haunches of the main arch to support the roadway at those points. There is an approach arch at each end of 70·84 ft. span. The boldness and novelty of the design of this bridge make it one of the most notable engineering works of modern times. The Cabin John arch, at Washington, D.C., has for many years ranked as the longest stone bridge in the world. It will now have to take second place, being 57·65 ft. shorter than the Luxemburg arch.

Glass-coating Metal Surfaces.—For obtaining this result, which protects the metals from external agencies, the *Moniteur Industriel* recommends that 120 parts by weight of flint-glass broken into pieces, 20 parts of sodium carbonate, and 12 parts of boric acid be melted together, and the mass in fusion run on to a hard surface, like marble or a metal plate, which must naturally be cold. When the substance is thoroughly cooled, it is to be pulverised and mixed with sodium silicate at a density of 50 degs. *B*. The mixture is then heated in a muffle, or simply in an oven, until a temperature is attained sufficient to produce the commencement of fusion, when a vitrified surface will be obtained, adhering perfectly well to metals, especially iron and steel.

The Andrew Carnegie Research Scholarships.—The Andrew Carnegie gold medal for 1902 has been awarded by the Council of the Iron and Steel Institute to Dr. J. A. Mathews, of New York, for the research carried out by him as a holder of an Andrew Carnegie Research Scholarship during the past year. The medal has been designed by Mr. G. W. de Saulles, of the Royal Mint. The first recipient, Dr. Mathews, has previously received a Fellowship for the encouragement of scientific research from Columbia College, New York, where he has been working under the guidance of Professor H. M. Howe. For the present year the Council of the Iron and Steel Institute has awarded six Andrew Carnegie Research Scholarships, each of the value of £100.

A Record in Liquid Fuel Travelling.—The steamship *Murex* has recently accomplished the longest recorded voyage under liquid fuel, the route being from Singapore to London by way of Capetown, the distance traversed being 11,830 miles. It is interesting to note that the total consumption of liquid fuel, including all purposes, was from 17 to 18½ tons per diem; whereas, had coal been employed, 24 to 25 tons of Welsh, or 30 to 32 of Japanese, would have been required. In addition to the actual saving in cost, the

economy in labour and increase of available cargo-carrying capacity must also be taken into consideration, when the advantages of the liquid fuel system would appear to be somewhat pronounced.

25,000-Volt Direct-Current Dynamo.—The Société Thury, of Switzerland, has recently constructed a 25,000 volt 25-kilo-watts direct-current dynamo, the speed being 600 revolutions per minute. The armature consists of 48 coils in slots. The fixed commutator has 98 segments with air insulation, and the revolving brushes make contact on the interior surface. An air pump on the independent exciter furnishes a blast to extinguish sparks at the commutator, the voltage between segments being 500.

Wireless Telegraphy in Italy.—The Italian Minister of Marine has received a favourable report from Captain Bonomo as to the trials, extending over seven months, with Signor Marconi's system of wireless telegraphy. The communications were distinct from one vessel to another, and also between a vessel and various stations along the coast. The instruments have already been purchased from the English Marconi Company for connecting Rome and Sardinia in this manner; and the system is to be adopted generally on vessels of the Italian Navy.

Water-Softening Plants.—The Metropolitan Electric Supply Co. have given instructions to Messrs. Mather & Platt, Ltd., to install a second plant for softening and purifying water by the "Archbutt-Deeley" process for an output of 10,000 gallons per hour. This, with the existing installation, will give a total capacity of 20,000 gallons per hour. Others who are adopting the "Archbutt-Deeley" system are the General Electric Supply Co., the Great Northern Railway of Ireland, Messrs. Bellis & Morcom, of Birmingham.

New and Powerful Explosive.—Some new cartridges for mine use are divided by a thin sheet of tin into two parts, one compartment containing a mixture of calcium carbide and baryum peroxide, while into the other is introduced, immediately before use, an acid which in a short time eats through the diaphragm and penetrates to the mixture, when a violent explosion ensues owing to the simultaneous formation of steam, hydrogen, and acetylene.

Large Steel Forgings.—A crank-shaft, 88 metres (288 ft.) long, with six throws, has been made by the Krupp firm at Essen, being one of the twin shafts intended for the *König Wilhelm II.*, now being built at Stettin, and which is to surpass in size and speed all vessels now afloat. The monster crank-shaft, which is valued at 300,000 marks (£15,000), has been sent to the Düsseldorf Exhibition.

An Ingenious Device.—A novel method is described in *The Gas World* for giving warning of the presence of smoke, the apparatus being as follows:—A silk strand or horsehair, when treated with a solution of caustic soda and dried in a vacuum, will lengthen when brought into contact with smoke; and this fact is utilised in the construction of an electrical apparatus which gives the requisite notice by ringing a bell.

A New Method for Hardening the Face of Castings.—"This process consists," says the *Foundry*, "of mixing pulverised sulphur with that part of the sand designed to come in contact with the portion of the casting it is desired to harden. It is said that by this system a face of greater density results than would otherwise be possible.

REVIEWS.

Verbal Notes and Sketches for Marine Engineers. By F. W. Sothern. Whittaker & Co.

This book is intended as an aid to those engineers who are preparing for the examinations for certificates of competency under the Board of Trade. It is well known that the examinations under the Board are of two kinds, written and oral. The book is for those who are preparing for the oral examination. Its plan is to take up each subject on which questions may be asked, and to explain to the reader the construction and working of the parts of marine machines. The description is mostly accompanied by a sketch of the part under discussion. These descriptions and sketches are suitable and clear. The book is divided under main headings—boilers, engines, engine-room auxiliaries, and then general notes on cast iron, wrought iron, steel, etc. There is a part on the indicator, and the methods of taking and calculating cards are shown. There is also an appendix, which deals with the Belleville and Babcock and Wilcox boilers. The refrigerating plant on board ship is described, and the system explained by means of a diagram.

It is to the advantage of the book that it has been written by one who is himself engaged in preparing engineers for the examination of the Board of Trade. He is in a position to know exactly what engineers require as aids to understand the questions which are put by the examiners. The book consists of 158 pages, and the type and figures are very clear. It is free from many errors which are very usual in such books, and can be safely recommended to all those who are preparing for the Board of Trade examinations.

Marine Boiler Management and Construction. By C. E. Stromeyer. Second edition. Longmans & Co.

In his preface to this second edition the author appears sorry that he had nothing before him of the evidence which led the present Boiler Committee for the Navy to bring in its interim report. It had been whispered—and there is a hint that the author heard the whisper of the Boiler Committee having made up its mind to bring in a white-washing report. In view, however, of the action of the Press, this was found to be an impossible attitude, and the Belleville boiler was condemned. Says the author—"The last Admiralty Committee on boilers, after collecting a thick volume of most valuable evidence, did not publish it in deference to the wishes of a few high-placed witnesses, and the same might happen again." The author is by this time assured the same is not likely to happen again.

Turning to the book itself, it may be pointed out that the very first paragraph happens to deal very fully with a subject which is agitating the public mind at the present day. That is the possibility of raising steam to working pressure quickly and safely in the Scotch boiler. As this is of so much interest now, we may give it to our readers in the author's own words:—

"If steam has to be raised quickly the fires are started in all the furnaces at once: but this should never be done unless there is steam in the donkey boiler, and appliances are available for producing artificial circulation. . . . In all cases of great hurry things are likely to go wrong, and it has happened over and over again that circumferential seams of boiler bottoms have cracked when not sufficiently warmed during this period. The circulating appliances used to be hydrokineters; now it is customary to fit a donkey suction to each boiler, by which means the cold water is drawn off there, and reintroduced through the feed near the water-level." It was with such an arrangement that one of the chief engineers in a cruiser got up steam in little over the hour, when ordered to do so quickly by the Admiralty. On reporting the same the Admiralty censured him for straining his boilers. A court-martial acquitted him.

The causes of corrosion in boilers are dealt with by the author, but he does not supply an answer to the various questions which have been from time to time anxiously asked. It is interesting to learn that in H.M.S. Crocodile from 425 lbs. to 630 lbs. of rolled zinc were consumed per boiler per annum. The author offers the following general remarks on the subject:—

"Strong chemicals, either alkalies or acids, should not be used. Certain salts increase or reduce the speed with which iron is attacked. Zinc salts appear to reduce the action, tin salts to increase it. Air being the probable cause of pitting, should be carefully excluded."

In the section on heat transmission the author makes no mention of what are probably the most interesting and valuable experiments which have been made on the subject—those of Blechynden and Yarrow. It was by the experiments of the former that we obtained the real laws of transmission, and by those of the latter the effects of heating in sections. It is by such experiments as those of Blechynden and Yarrow that the practical engineer is led to see in what direction improvement in boiler construction may be sought.

There is a section on the construction of boilers, which is fully illustrated. The manner in which the plates are rolled is shown, and the methods of construction fully discussed. The Board of Trade boiler rules are dealt with last. It is known that the author has strong opinions on the question. He has very fully investigated the rules, and does not find that they rest on a scientific basis. The rules are mainly rules of thumb. There is not the least necessity for scantlings of the dimensions required by the Board of Trade in many cases. The author thinks advantages would accrue if the rules were placed on a better footing.

The book consists of 404 pages, and it is excellently printed. The tendency is possibly towards theoretical considerations and aims, but the author cites innumerable cases of mishap, and gives good practical advice. Sometimes the practical point is missed, the author apparently possessing a preference for pure science. But, on the whole, the work may be classed as a mine of information and an absolutely safe guide on all the matters with which it deals.